

ORIGINAL



0000166520

RECEIVED
AZ CORP COMMISSION
DOCKET CONTROL

Memorandum

From the office of

Commissioner Bob Burns

Arizona Corporation Commission

1200 W. WASHINGTON

PHOENIX, ARIZONA

(602) 542-3682

Arizona Corporation Commission

DOCKET CONTROL

OCT 28 2015

DOCKETED
[Signature]

TO: Docket Control

DATE: October 28, 2015

FROM: Commissioner Bob Burns

SUBJECT: Emerging Technologies in Energy, Docket No. E-00000J-13-0375

The agenda and presentations from the October 27, 2015 Emerging Technologies Workshop have been docketed. If for some reason you cannot access eDocket, please contact my Executive Aide, Jessica Perry, to receive copies of the presentations.

Original and thirteen (13) copies of
the agenda and presentations filed this 28th day of
October, 2015, with:

Docket Control
Arizona Corporation Commission
1200 West Washington Street
Phoenix, Arizona 85007

Copies of the memo mailed
this 28th day of October, 2015, to:

Service List

REVISED NOTICE
SPECIAL OPEN MEETING
OF THE ARIZONA CORPORATION COMMISSION

Commission Workshop on Emerging Technologies
Docket No. E-00000J-13-0375

DATE: Tuesday, October 27, 2015

START TIME: 9:00 a.m.

Arizona Corporation Commission
Hearing Room **One**
1200 W. Washington Street
Phoenix, Arizona 85007

This shall serve as notice of a special open meeting of the Arizona Corporation Commission at the above location for consideration, discussion, and possible vote of the items on the following agenda and other matters related thereto. Please be advised that the Commissioners may use this open meeting to ask questions about the matters on the agenda; therefore, the parties to the matters to be discussed or their legal representatives are requested, though not required, to attend. The Commissioners may move to executive session, which will not be open to the public, for the purpose of legal advice pursuant to A.R.S. §§ 38-431.03.A.2, 3 and/or 4 on the matters noticed herein. The Commissioners may also move to executive session, which will not be open to the public, for other purposes specified in A.R.S. §§ 38-431.03, including discussions, consultations or considerations of Commission personnel and salary matters, on matters noticed herein.

The Arizona Corporation Commission does not discriminate on the basis of disability in admission to its public meetings. Persons with a disability may request a reasonable accommodation, such as a sign language interpreter, as well as request this document in an alternative format, by contacting Shaylin A. Bernal, phone number (602) 542-3931, E-mail sabernal@azcc.gov. Requests should be made as early as possible to allow time to arrange the accommodations.

Jodi Jerich
Executive Director

Agenda

Morning Session: 9:00 a.m.

Welcome & Opening Remarks

Presentations:

1. Clean Energy Collective
Tom Hunt, Vice President of Corporate Development
"Community Solar Opportunities and Best Practices"

2. Proctor Engineering Group
Tom Downey, Chief Technical Officer
“Emerging Opportunities for HVAC Energy Efficiency Programs in Arizona”
3. Invenergy, LLC
Chris Orzel, Manager of Energy Storage Originations & Market Development
“Maximizing the Value of Existing Grid Assets Position”
4. Tucson Electric Power
Carmine Tilghman, Senior Director of Energy Supply
“TEP Update on Utility Owned Distributed Generation”
5. Arizona Public Service
Marc Romito, Manager of Renewable Energy
“Strategic Path to Sustainable Distributed Energy Resources”

Lunch

Afternoon Session

Presentations:

6. AES Energy, Inc.
Kate McGinnis, Market Director of Western U.S.
“Energy Storage for Clean, Affordable, Unbreakable Grid”
7. JLM Energy, Inc.
Farid Dibachi, CEO and Chief Products Officer
“Energy Storage: The Final Frontier in Self-Generation”
8. SolarCity
Kevin Joyce, Manager of Grid Engineering Solutions
“Unlocking the Potential of Distributed Energy Resources”
9. Tierra Resource Consultants, LLC
Marshall Keneipp, Principal
“The APS Solar Innovation Study”
10. OPOWER
Josh Lich, Director of Product Marketing
“Using Advanced Analytics to Increase Program Participation”

Wrap-Up & Closing Remarks



Community Solar Opportunities & Best Practices

ACC Emerging Technologies Workshop 2015

10/27/15



Clean Energy Collective | Community Solar



► **Nation's leading community solar provider**

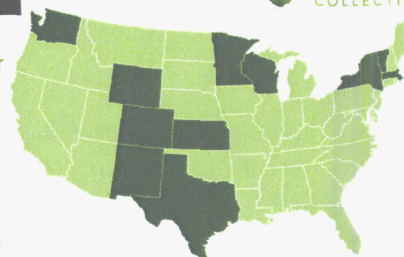
- 25 utility partners spanning 11 states
- 50+ community solar facilities and growing
- In conversations with over 160 utilities

► **Focused solely on community renewables**

- Built the nation's first and largest community-owned solar facilities
- More community solar built than all other vendors combined
- Recognized by DOE, SEPA, Solar Foundation, and others for leading program design

► **Partners in local communities to provide utility and consumer value**

- Worked with utilities from small rural cooperatives to nationwide IOUs
- CEC can fully fund, build, and administer projects – or simply provide tools
- Community Solar Platform line of products allows partners to use CEC's tools



History | Then and Now



Source:
NREL (Heeter 2014)

THEN

- ▶ 2006 – Ellensburg, WA – 36 kW – city owned
- ▶ 2010 - Holy Cross (El Jebel, CO) – 86 kW - "community-owned"
- ▶ 2010 – NREL's "Guide to Community Solar"

NOW

- ▶ 110 projects and 74 MW (as of May)
- ▶ 2015 estimate - cumulative capacity at 180+ MW
- ▶ 2015 coined "tipping point" year with five-fold increase in annual capacity

10/26/2015

© Copyright 2015 Clean Energy Collective

3

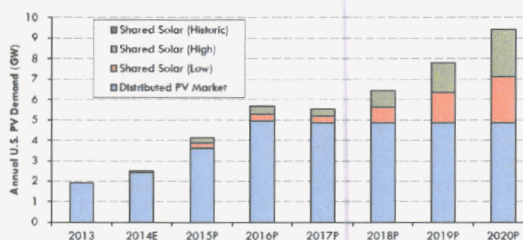
Future Market | Potential & Projections



▶ **U.S. DOE & NREL on market potential (by 2020):**

- 5.5-11 GW cumulative capacity
- \$8.2-\$16.3 billion investment
- 32%-49% of PV DG market

Source: DOE/NREL (April 2015)

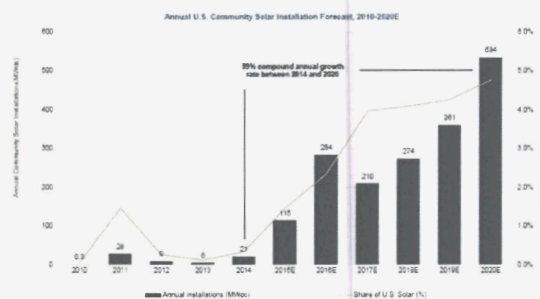


▶ **GTM Research projections:**

- 59% compound annual growth rate between 2014-2020
- Over 1,800 MW installed from 2015-2020
- 530+ MW installed in 2020 alone

"most significant U.S. solar growth market"

Source: GTM Research (May 2015)



10/26/2015

© Copyright 2015 Clean Energy Collective

4

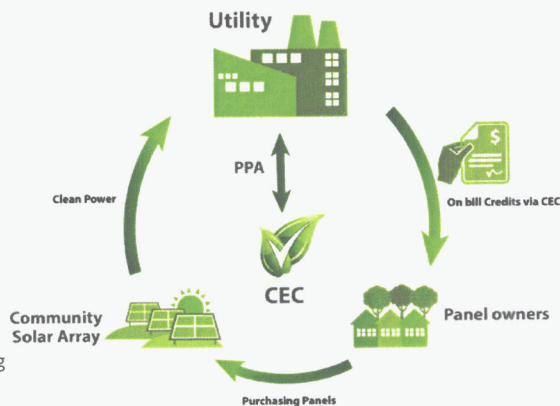
Community Solar | How does it work?



Community solar allows multiple subscribers to own an interest in a solar project and receive on-bill credits associated with the system's production. Projects can be sponsored by utilities or third parties (if allowed).

Example (3rd-party model)

1. Utility and developer partner to interconnect centralized solar array.
2. Developer owns system and sends all generation to the utility via PPA.
3. Utility provides compensation for generation via monthly on-bill credits to participating customers (based on participation interests in the project).
4. Developer responsible for establishing individual contracts with participants (capacity or energy based), and all related marketing and administration.



10/26/2015

© Copyright 2015 Clean Energy Collective®

5

Policy | States with Community Solar policy



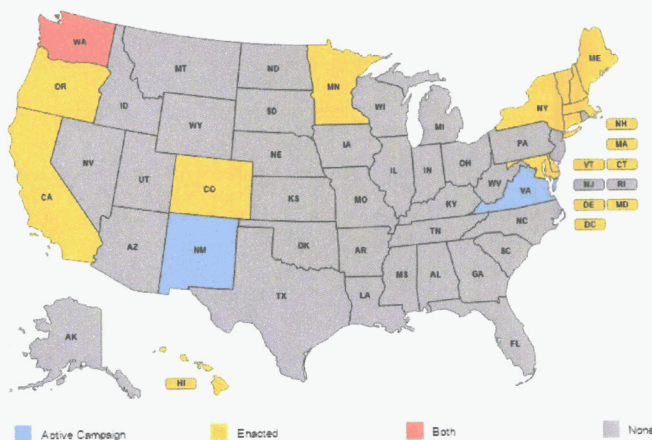
- ▶ 13 states + DC with some form of CS policy

- ▶ Map is conservative estimate for states w/ "active campaign"

- Legislation introduced and/or campaigns developing in other states (MI, IL, NV, MT, others)

- ▶ Utility-led programs may be largest area of growth

- Doesn't capture states with independent utility programs, proposals or explorations (AZ, SC, FL, WI, ID, IL, TN, others)



Source: VoteSolar: Shared Renewables HQ
(10/26/2015)

10/26/2015

© Copyright 2015 Clean Energy Collective®

6

Community Solar | Utility-led Programs



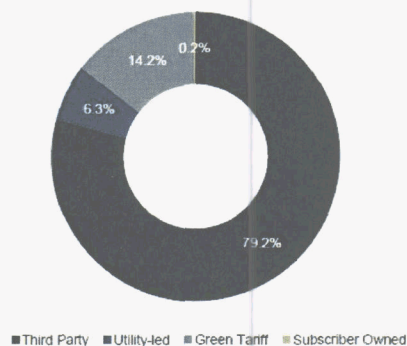
► **2014 SEPA report on utility-led community solar:**

- Utility programs represent 87% of programs online;
- 60% of active and planned community solar systems;
- 96% of all active/planned community solar capacity.

► **Not yet delivering significant capacity though:**

- 80% of operating and pipeline capacity is third-party led (GTM Research)

U.S. Total Operating and Pipeline Archetype Distribution



Source: GTM Research (May 2015)

10/26/2015

© Copyright 2015 Clean Energy Collective®

7

Benefits | Utility and Grid Operations

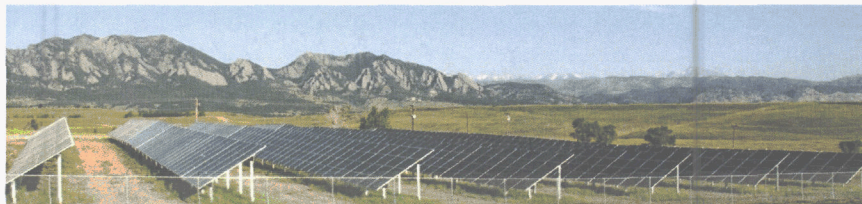


► **Systems can be located to benefit, rather than hinder, grid operations**

- Developers and utilities can work together to locate systems to enhance, rather than congest, the grid's ability to operate efficiently
- e.g., New York's Community Shared Renewables Program includes the identification of "Opportunity Zones"

► **Systems can be configured to optimize production based on utility needs**

- For example, if greater benefits are gained via western orientation rather than southern, or via tracker rather than fixed tilt



10/26/2015

© Copyright 2015 Clean Energy Collective®

8

Benefits | Reaching All Customers



- ▶ **Community solar allows for participation by all ratepayers: individuals, businesses, government, non-profits, etc.**
 - U.S. DOE (April 2015) estimates ~50% of households and businesses are unable to host a PV system due to property constraints
 - GTM Research (May 2015) estimates 77% of households are locked out of the onsite rooftop market when accounting for policy and financial considerations
- ▶ **Unique opportunity to reach underserved segments of the population, and / or achieve policy objectives**
 - Community solar is much better positioned to reach low-income ratepayers, and can provide targeted programs
 - E.g., Colorado's 5% carve out; California's Environmental Justice 100 MW carve out
- ▶ **Benefits to the customers without the headaches of rooftop ownership**
 - Offers a convenient, lower risk and zero-maintenance option for customers interested in the benefits of solar
- ▶ **The utility also benefits from this opportunity provided to ratepayers**
 - Programs can improve on and cultivate further customer-utility relationships, and allow customer engagement with solar via digital tools
 - May allow engagement in other beneficial utility programs (EE, DSM, etc.)

10/26/2015

© Copyright 2015 Clean Energy Collective®

9

Benefits | Flexibility in Crediting Rate



- ▶ **On-bill credits are essential!**
 - Otherwise payments will run afoul of securities law and market will be limited
 - Credits can be structured differently - \$/kWh, kWh offset, etc. – but they have to exist
- ▶ **Credit rate itself can be set in different ways:**
 - Negotiated PPA with utility
 - Value of Solar
 - Rate structure set by statute
 - Net metering with customer accounts
- ▶ **Flexible to meet the interests of participants and all ratepayers**
 - Can be designed to provide the customer with an economic benefit, while allowing for reasonable recovery of costs by the utility, and in turn avoiding major cost shifts



10/26/2015

© Copyright 2015 Clean Energy Collective®

10

Benefits | **Scale**

► **Economies of scale for participants**

- Larger systems are significantly less expensive to install
- Operations and maintenance handled professionally, for the long term

► **Scale can also benefit the utility**

- Better system integration with larger 'utility scale' plants and operations – utilities are better able to manage and control and thus take advantage of the benefits to the grid
- Can be integrated with resource planning more effectively, and allow for programs that can run smoothly over a period of time



10/26/2015

© Copyright 2015 Clean Energy Collective®

11

Conclusion | **Community Solar Works**

- **Community solar is the fastest growing solar market segment, and is anticipated to stay that way for the foreseeable future.**
- **It provides a unique solution to meeting the interests of solar advocates, non-participants, and the utility**
- **It can be flexible in design and administration and can result in increased goodwill and relationship cultivation between the customers and utility**
- **It works!**



10/26/2015

© Copyright 2015 Clean Energy Collective®

12



Clean Energy
COLLECTIVE®

Thank you!



Tom Hunt
VP of Corporate Development
203-417-4027
tom.hunt@easycleanenergy.com

Proctor Engineering Group

Emerging Opportunities for HVAC Energy Efficiency Programs in Arizona

Tom Downey

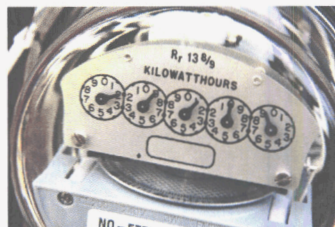


Proctor Engineering Group, Ltd.
88 E Broadway Blvd
Tucson, AZ 85701



Proctor Engineering Group

- Specializing in HVAC research, product development, and program implementation since 1989
- Developed the CheckMe!® Quality Assurance system in 1997
- Trained more than 2,000 HVAC contractors and 7,500 service technicians who have serviced over 350,000 HVAC systems nationwide, using CheckMe!®
- Currently administering TEP and UNS Energy Efficient Home Programs



Recent PEG Research Projects

- CEC Central Valley Research Homes Project (Ongoing)
- Kingdom of Saudi Arabia High EER at 46°C Air Conditioner Project
- CEC Efficiency Characteristics and Opportunities for New California Homes
- CEC/IOU Energy Performance of Hot/Dry Optimized AC Systems
- SMUD Service Light Unit (Onboard Fault Detection Diagnostics)
- Field Research with "Smart Thermostat" Manufacturer

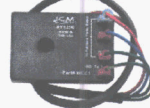


PEG Energy Efficient Products

- Concept 3™ BPM Fan Motor



- Western Cooling Control™



- Hairrell Heat Pump Control™



- Fieldpiece Charging Jacket™



- Other Technologies Currently Under Development



Arizona Potential

- The U.S. Energy Information Administration estimates:
 - 87% of Arizona homes have central air conditioning
 - Arizonans spend approximately 25% of their home energy budget on air conditioning
- Air conditioning use is essential for virtually all Arizona businesses
- Most of the following emerging technologies apply to both residential and commercial customers
- All of the following emerging technologies are commercially available, have a long useful life, are cost effective, and will benefit Arizonans



Smart Thermostats

- Ethernet or Wi-Fi communicating thermostats
- Two types of systems:
 - Software supporting certain communicating thermostats



- Software and hardware bundled by manufacturer



- Can provide both energy savings and demand response
- Applicable to all Arizona residential and commercial customers
- Included in TEP and APS plans for 2016



Smart Thermostats

- Energy savings provided through multiple approaches
 - Learning occupant behaviors and making small adjustments
 - Customer feedback on energy savings
 - Sensing when space is unoccupied
 - Optimizing heat pump performance to avoid auxiliary heat
 - Optimizing indoor fan run times
- Smarter Demand Response control
 - Ability to precool the building in advance of a DR event
 - High level of customer acceptance compared to traditional DR
- Energy savings claims in the range of 10% to 20%



Smart Controls

- Western Cooling Control™ indoor fan controller
 - Based on PEG hot/dry climate specific air conditioner research
 - Water is on the inside coil when the compressor shuts off
 - Evaporating the water off the coil recovers the wasted capacity

• How the WCC™ Works

Standard Air Conditioner

- Compressor on - Fan on
- Compressor off
 - Fan off or
 - Fan off in 60 - 90 seconds

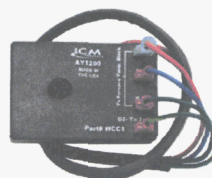
Air Conditioner with WCC™

- Compressor on - Fan on
 - Compressor on time logged
- Compressor off
 - Fan run time varies with logged compressor time
 - Evaporates water off coil = Cool air



Smart Controls

- Energy savings are well documented in laboratory and field
 - Same methodology manufacturers use to get increased SEER ratings
 - Average CEC field monitored cooling savings of 16%
 - Multiple NV Energy impact evaluations found savings up to 18%, averaging 10% - 12%
- Applicable to retrofits as well as new installations for both residential and commercial HVAC systems
- Low cost, easy to install measure that enhances HVAC program cost effectiveness
- Included in TEP and APS plans for 2016



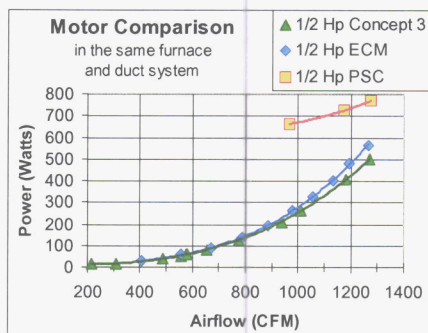
Brushless Permanent Magnet Motors

- Brushless Permanent Magnet motors (BPM) are an ideal replacement for Permanent Split Capacitor (PSC) fan motors found in most furnaces
- BPM motors became readily available for HVAC retrofits around 2008, but still represent a small fraction of the replacement market
- BPM's provide year round energy savings. Savings increase at lower airflows during the heating season
- Retrofit BPM motor prices have dropped significantly in the last 2 to 3 years, making them competitive with PSC motors



Brushless Permanent Magnet Motors

- BPM motors reduce fan motor watt draw by roughly half compared to PSC motors, and up to 80% in constant circulation mode
- Energy savings are dependent on duct system design and are lower in poorly designed duct systems
- Included in TEP plan for 2016



Inverter Driven HVAC Systems

- Inverter driven systems, sometimes referred to as variable refrigerant flow systems, vary compressor and fan motor speeds to meet the cooling and heating needs of the building
- Two common types of systems
 - Ductless and ducted mini-splits and multi-splits
 - Traditional ducted systems
- SEER and HSPF ratings are much higher than traditional air conditioners and heat pumps, reaching SEER levels as high as 25
- Most major manufacturers have adopted inverter technology and have traditional ducted systems available
- Mini-splits and multi-splits eliminate duct system losses



Inverter Driven HVAC Systems

- Current SEER and HSPF rating methods are not well suited to the technology and need to be revised
- Multiple studies have found that actual installed performance of mini-splits and multi-splits do not meet the manufacturers' claimed efficiency
- Peak demand reductions don't necessarily follow expectations based on SEER or even EER ratings
- Currently no consistent or achievable field verification test that can assure contractors or utilities that these systems are operating at their rated efficiency



Advanced Rooftop Unit Controllers

- Advanced RTU Controllers (ARC) use variable-frequency drive technology to modulate the cooling capacity to meet the needs of the building.
- ARC's provide advanced economizer controls, fault detection diagnostics, and Demand Response capabilities
- ARC's achieve energy savings by controlling standard single speed and multi-stage RTU's by varying the fan speed and utilizing economizer cooling when appropriate
- A Pacific Northwest National Laboratory (PNNL) study of 66 RTU's found ARC's reduced the annual RTU energy consumption between 22% and 90%, with an average of 57%



Advanced Rooftop Unit Controllers

- The PNNL study found:
 - Fan energy savings was the dominant contributor while cooling and heating savings varied and were relatively small in comparison with fan energy savings
 - Average payback periods were 6, 3, and 2 years for the 3 utility rates (\$0.05, 0.10, and 0.15 / kWh)
 - Demand reduction and demand cost savings were not considered. Demand reduction could have significant impact on the simple payback period
 - Estimated cooling energy savings for Phoenix range from 39% to 44%



Additional Opportunities

- While not emerging technologies, PEG has found the following measures to deliver reliable, cost effective savings:
 - Return air upgrades
 - Reconfiguring and burying duct systems under attic insulation
 - Targeted early replacement of inefficient HVAC systems
 - Hairrell Heat Pump Control™
 - Nighttime pre-cooling with smart whole house fans



Proctor Engineering Group

Questions?

Tom Downey

Proctor Engineering Group, Ltd.


418 Mission Avenue

San Rafael, CA 94901



Phone (415) 717-0121


tom@proctoreng.com





Invenergy Storage

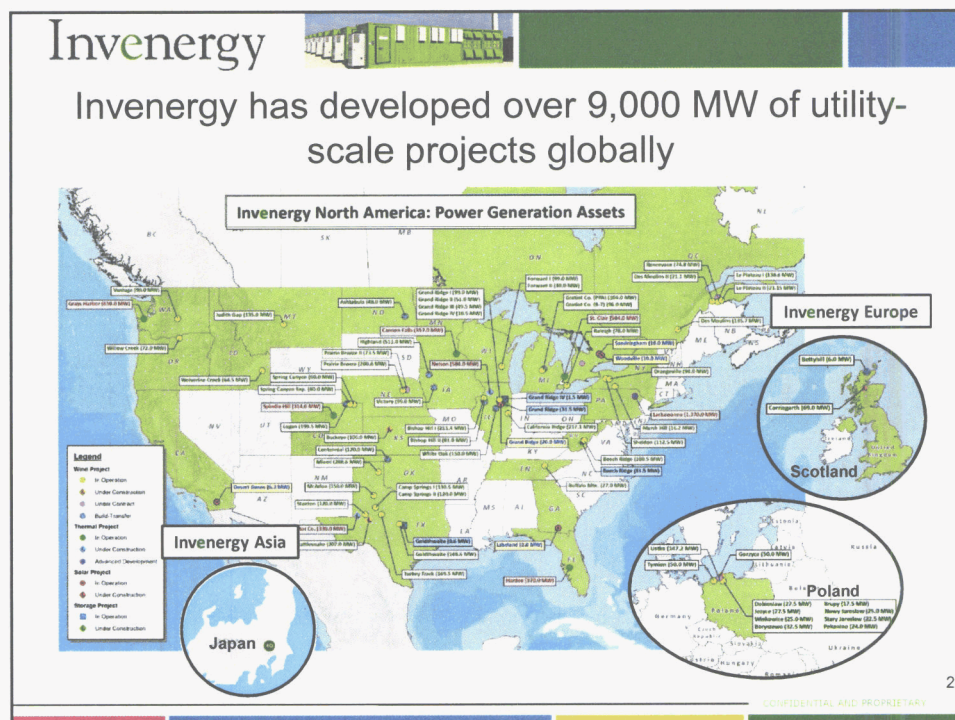


ACC - Commission Workshop on
Emerging Technologies

October 27, 2015
Phoenix, AZ

Chris Orzel

CONFIDENTIAL AND PROPRIETARY



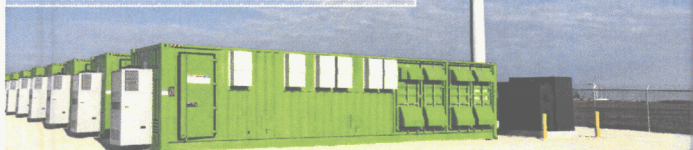
Invenergy



Invenergy is a leader in the quickly developing market for advanced energy storage systems

GRAND RIDGE ENERGY STORAGE

- 31.5 MW Li-ion advanced energy storage project – COD 2015
- Provides dynamic regulation service (DREG) to PJM
- Began with a 1.5 MW / 1.0 MWh pilot energy storage project in 2012



PROJECT	SIZE
Grand Ridge IV Storage	1.5 MW / 1.0 MWh
Goldthwaite Storage	0.6 MW / 1.2 MWh
Grand Ridge Energy Storage	31.5 MW / 12.2 MWh
Beech Ridge Energy Storage	31.5 MW / 12.2 MWh
Grand Ridge IV Storage Expansion	3.0 MW / 1.4 MWh

5 ENERGY STORAGE PROJECTS IN THE US

68 MW OF NAMEPLATE CAPACITY

#1 PRIVATELY HELD ADVANCED ENERGY STORAGE OWNER/OPERATOR

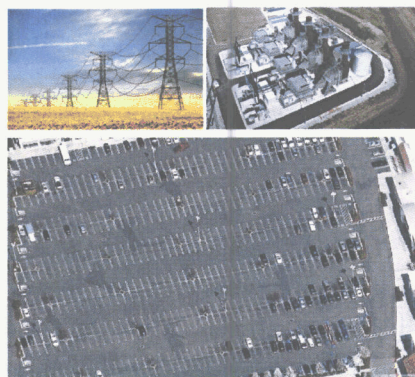
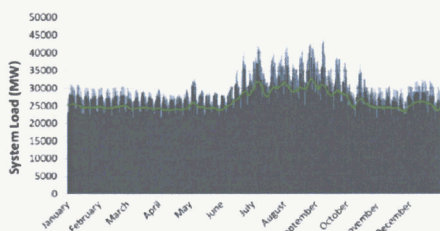
3

CONFIDENTIAL AND PROPRIETARY

Invenergy



We've built the electric grid like shopping mall parking lots...



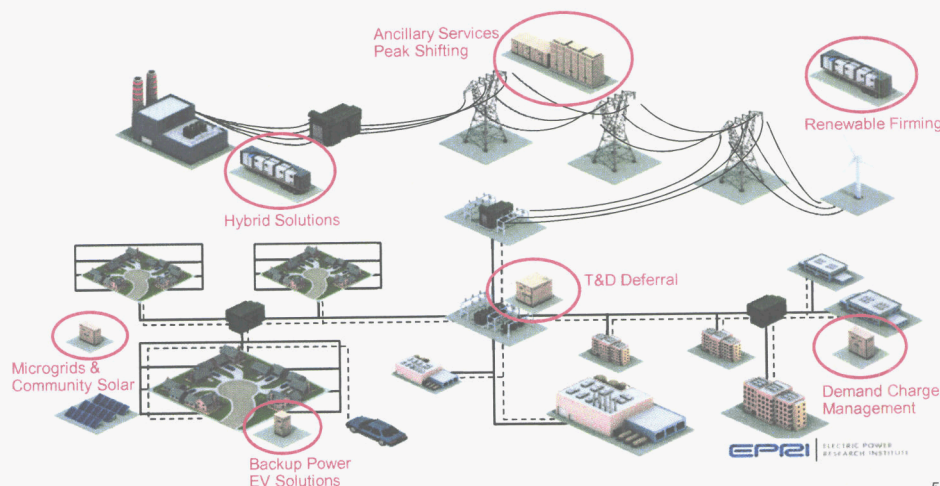
4

CONFIDENTIAL AND PROPRIETARY

Invenergy



...but, is there a more efficient way to run the grid with the same or even greater reliability?



Source: <http://www.sustainableimov.com/applications/grid-energy-storage/> and Invenergy

CONFIDENTIAL AND PROPRIETARY

5

Invenergy



Today's advanced energy storage systems are capable of providing numerous services

IN FRONT OF THE METER

- Regulation Up
- Regulation Down
- Spinning Reserve
- Non-spinning Reserve
- Voltage Control
- Reactive Support
- Frequency Response
- Renewable Firming
- Peak Shifting
- Black-Start
- Ramp Control
- Capacity
- Flexible Capacity
- Energy
- Congestion Relief
- T&D Upgrade Deferral

BEHIND THE METER

- Demand Charge Management
- Backup Power
- Power Quality
- Demand Response
- Permanent Load Shifting
- Microgrids
- Reduced GHGs
- Solar Integration
- Grid Resiliency
- EV Charging

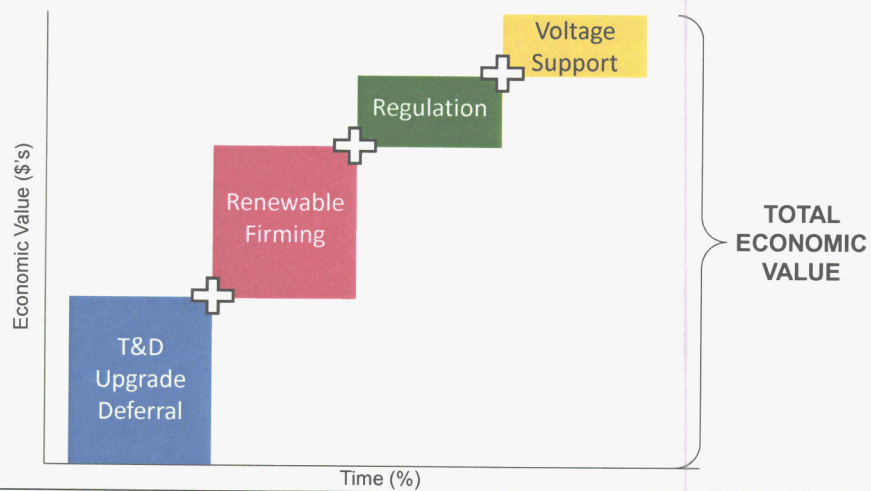
CONFIDENTIAL AND PROPRIETARY

6

Invenergy



Performing multiple services allows you to maximize value from a storage resource and optimize the efficiency of existing assets



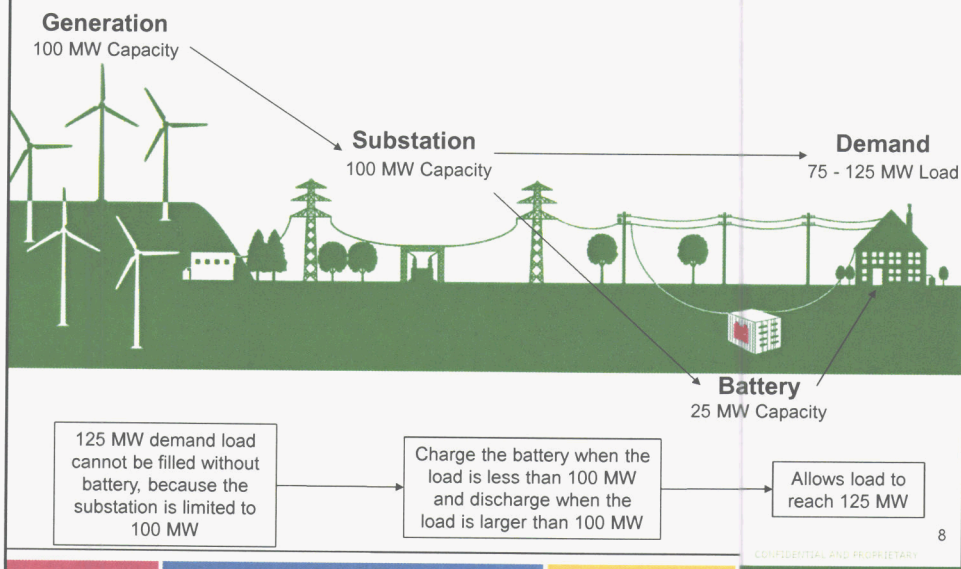
CONFIDENTIAL AND PROPRIETARY

7

Invenergy



T&D Upgrade Deferral Example



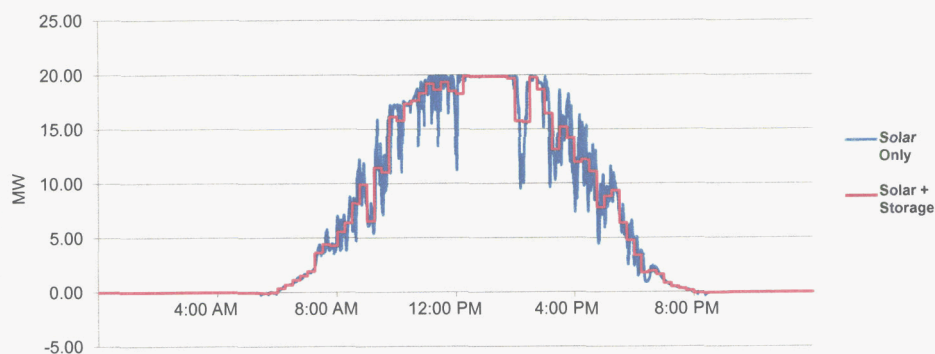
CONFIDENTIAL AND PROPRIETARY

8

Invenergy



Renewable Integration Solar Firming Example



- Renewable output variability creates scheduling challenges
 - 20 MW solar farm output over one day with 1 second data
 - Using a 4 MW battery, all variations can be smoothed to create 15 minute firm blocks of energy and reduce energy imbalances

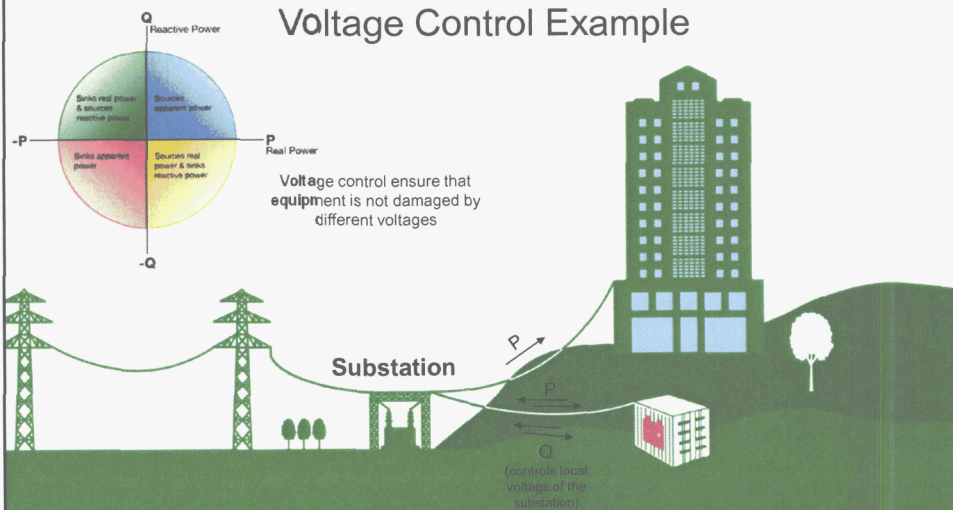
9

CONFIDENTIAL AND PROPRIETARY

Invenergy



Ancillary Services Voltage Control Example



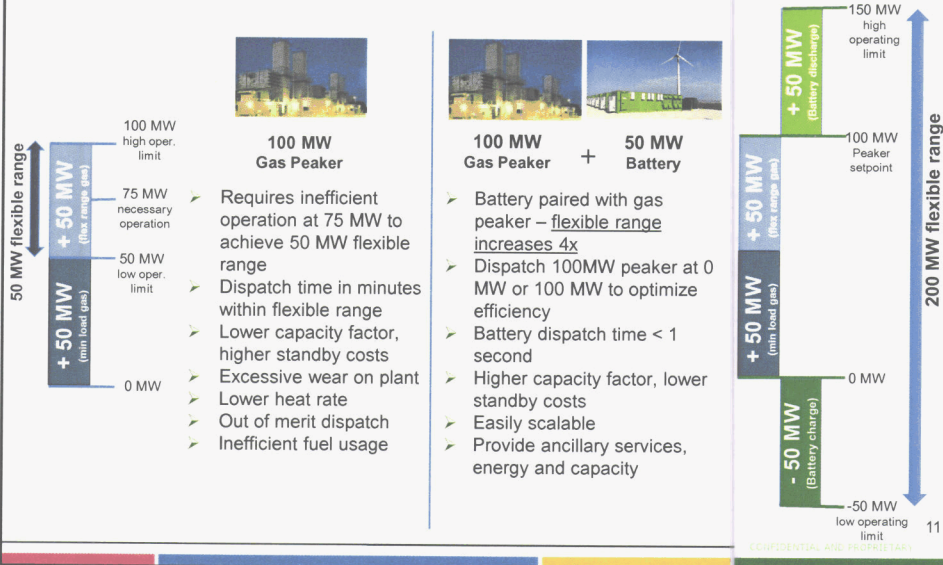
Battery adjusts reactive power to match voltage to grid (see graph above)

10

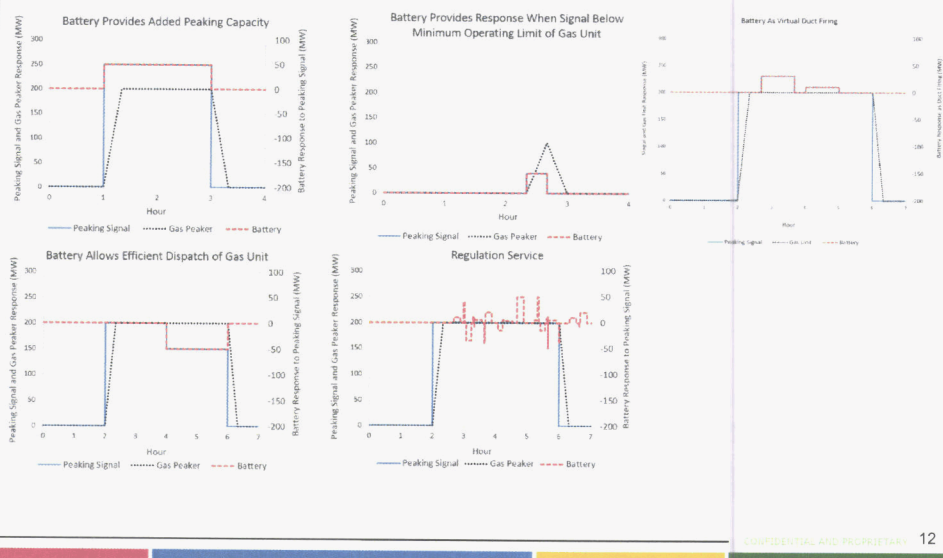
CONFIDENTIAL AND PROPRIETARY



Optimizing Thermal Generation Example



Battery / Thermal Hybrid Optimized Systems

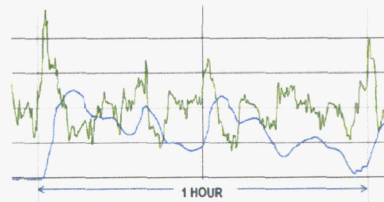




Regulation / Frequency Response Example (PJM)

Regulation resources within PJM can provide service one of two ways:

- **Traditional Regulation Signal (RegA)**
 - A function of slow filter of RTO area control error (ACE), ramp is slower at 4 miles per hour
 - Can remain in full raise or lower for extended periods (30-60 minutes)
 - Steam units, Combined Cycle units, Some Combustion Turbines (CT)
 - Units can receive lost opportunity cost, but not benefit factor
- **Dynamic Regulation Signal (RegD)**
 - A function of fast filter of RTO ACE, ramp is faster at 12 miles per hour
 - Adds energy neutrality within 5 minutes
 - Energy Storage, Hydro, Some CTs
 - Units eligible to receive all market payments



Blue: RegA signal
Green: RegD signal

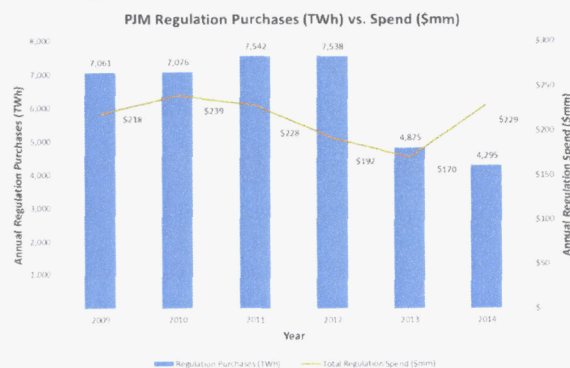
Source: PJM Performance Based Regulation Phase 1 Training, 6/26/2012

13

CONFIDENTIAL AND PROPRIETARY



Advanced energy storage has resulted in PJM procuring ~40% less of regulation annually



Source: PJM, Market Monitor State of the Market Reports, Invenergy

- In 2013, the first full year of PJM's dynamic regulation signal total regulation purchases dropped to 4,825 TWh from 7,538 TWh the year prior.
- Total regulation spend has also declined from a pre-implementation peak of \$239mm annually, to \$170mm in 2013.
 - Uptick in 2014 an anomaly due to Polar Vortex impact in 1Q 2014 on overall energy prices

14

CONFIDENTIAL AND PROPRIETARY

Invenergy



Questions and Contact Info

Questions

Contact Information:

Christopher Orzel

312-582-1430

COrzel@invenergyllc.com

CONFIDENTIAL AND PROPRIETARY 15



Update: TEP Owned Distributed Generation Program



October 27, 2015

Carmine Tilghman
Senior Director – Energy Supply

TIMELINE

- December 18, 2014 – Program approval, established customer interest list.
- February, 2015 – Vendor contracts and product selection completed.
- April, 2015 – Soft launch (initial 30 customers) to train installers, test procedures, etc.
- June 18, 2015 – First system installed & operational.
- July 1, 2015 – First public offering to participate in program for those signed up on interest list (3,400 customers). Limited to first 200 applications, received in approx. 20 minutes.
- Sept 8, 2015 – Second public offering. Limited to first 200 applications started, received in 1 minute.



TOTAL RESIDENTIAL NUMBERS

	TEP Owned Residential Solar	+	Residential DG	=	Total
TORS Pre-Qualified/ Applications Received:	402 2.64 MW DC		3,393 24.10 MW DC		3,795 26.74 MW DC
TORS Contracts Signed/ Applications Approved:	112 0.66 MW DC		3,324 23.71 MW DC		3,436 24.37 MW DC
Total Installations:	22 0.13 MW DC		2,517 18.10 MW DC		2,539 18.23 MW DC
Lifetime Installations:					9,686 64.07 MW DC



1/1/2015 THROUGH 10/27/2015

TEP OWNED RESIDENTIAL SOLAR PROGRAM PRE-QUALIFICATION NUMBERS

Interest List:	4,789	
Total Pre-Qualified Applications:	616	
Total Qualified Customers	507	82%
Total Disqualified Customers	109	18%

Reason:

Low Customer Score:	47	43%
Usage does not meet minimum requirement:	52	48%
Low Customer Score & Usage does not meet minimum requirement:	5	5%
Customer Elected to not move forward	5	5%



1/1/2015 THROUGH 10/27/2015

TEP OWNED RESIDENTIAL SOLAR PROGRAM

SITE VISIT NUMBERS

Total Prequalified	402	Does not include Technical Disqualifications or Customer Cancelled
Total Contracts Pending/Executed	155	
Customer Site Visits Pending	68	All Customers have been contacted by our Alliance Contractors. Date of scheduled site visit pending.
Currently Scheduled Site Visits	179	
Technical Disqualifications	42	

Dis-Qual Reasoning:

Limited solar access (roof space, orientation, shading, etc..)	18
Roof or house in poor condition	7
Service entrance in conflict with EC-1340	13
Service entrance in poor condition	3
Permit Issue exist, prohibiting installation	1



1/1/2015 THROUGH 10/27/2015

TEP OWNED RESIDENTIAL SOLAR PROGRAM

CONTRACT NUMBERS

Total Contracts Created	218	
Contracts in 14 day Window	43	
Total Contracts Signed	112	64%
Customers Cancelled	63	36%

Cancellation Reason:

No Longer Interested / Unresponsive	51
Contract Length	5
Savings	4
Future Home Repairs	3



1/1/2015 THROUGH 10/27/2015

TEP OWNED RESIDENTIAL SOLAR PROGRAM INSTALLATIONS

	Count	kW DC
Total Systems In Service	22	127.98
Pending Installations	90	530.82



1/1/2015 THROUGH 10/27/2015

TEP OWNED RESIDENTIAL SOLAR PROGRAM FINANCIAL FORECASTING

Pre-Qualified Projects:	\$ 4,171,833.40	
Projects in Process:	\$ 1,130,013.79	Cost Per Watt: \$2.13
Installed Systems:	\$ 262,052.64	Cost Per Watt: \$2.05
Recorder Fees / MISC:	\$ 3,618.00	
Grand Total:	\$ 5,567,517.83	



1/1/2015 THROUGH 10/27/2015

R&D PROJECT: WEST INA SUBSTATION

- Goal: Increase energy delivery efficiency/cost avoidance through the use of DER resources, controller, and communications network.
- Targeted customers fed through West Ina substation under utility-owned DG program.
- Need control methodology to control all the DER technologies in order to solve overload or low voltage issues on individual distribution feeders.
 - Control system to provide remote control and distribution system situational awareness for the distribution system operators, integrated into a Distribution Management System (DMS).
 - DER devices need to be controlled in synchronization to optimize effectiveness in dynamic load condition.

1/1/2015:1 THROUGH

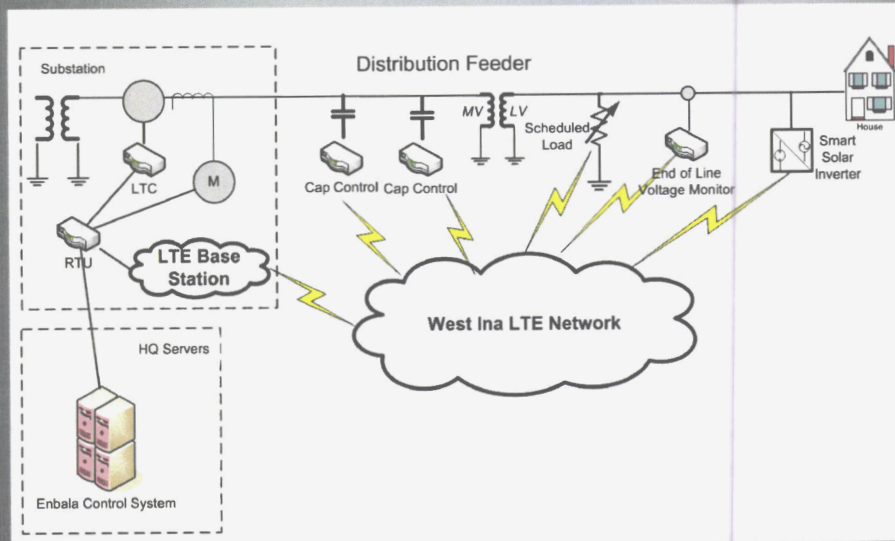
10/27/2015

R&D PROJECT: WEST INA SUBSTATION

- Communications network required following:
 - Low end point cost
 - Easy installation
 - High security & encryption
 - Licensed frequency spectrum
 - High bandwidth capabilities
- Spectrum & product search determined 3.65 GHz LTE network most viable
- LTE network required to enable measurement & control of DER devices and measurement of distribution feeder electrical parameters.
- Should have operational by mid 2016

1/1/2015:1 THROUGH

10/27/2015



1/1/2015:1 THROUGH

10/27/2015

Strategic Path to Sustainable Distributed Energy Resources (DER)

Arizona Corporation Commission Technology Workshop

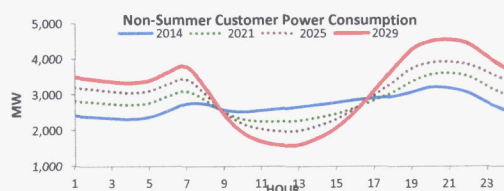
Marc Romito
Manager, Renewable Energy

October 27, 2015



Why Solar R&D?

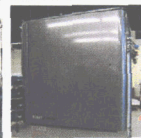
- Continuing increase in penetration of rooftop solar is causing...
 - Impacts to the grid
 - Voltage excursions
 - Operational challenges; reverse power flows, no control
 - Reduced ability to efficiently plan system improvements
 - Impacts to customers
 - Cost shift due to net metering
 - Declining ability to add behind the meter technologies
- Current R&D within industry
 - Small scale
 - Limited scope
 - Few variables





Desired End-State: Grid as Enabler

- Monitor/control customer technology impacts
 - Advanced inverters
 - Communications infrastructure – security/resiliency
 - Power quality
 - Curtailment
- Align customer technology with system needs via rate structure
 - Tie Distribution System Planning to available and future customer-sited resources
 - Tie customer Distributed Energy Resources (DER) to Advanced Distribution Management System (ADMS) environment

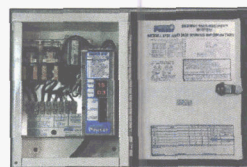
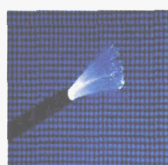


3



APS Solar R&D Initiatives

- **Solar Partner Program (SPP)**
 - APS owned rooftop solar research and development program aimed at learning how to efficiently enable the integration of rooftop solar and battery storage with our grid
- **Solar Innovation Study (SIS)**
 - A 75 customer field home energy management and rate research and development program to examine the integration of behind the meter advanced technologies with demand-based rates



4



Solar Partner Program (SPP)

- Install rooftop solar on 1,500 homes with smart inverters and full 2-way communications to control each rooftop solar site
- Install 2MW of battery storage on 2 selected feeders
- Collect and analyze real time data on energy production, energy usage, power regulation capabilities, and curtailment options



5



Solar Partner Program (SPP) Benefits

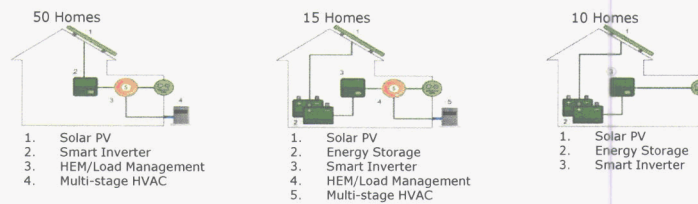
- Proof of ability to actively manage effects of solar by configuring smart inverters and issuing real-time commands in a cyber secure environment
- Validation of ability to mitigate adverse effects of increased photovoltaic (PV) through enhanced power regulating capabilities
- Validation of ability to provide ancillary services from a series of grid-tied batteries in coordination with solar inverters and traditional grid devices
- Collection and analysis of information that helps anticipate, identify and avoid impacts on the distribution grid
- Verification of distribution system models to be used in more accurately and efficiently planning grid upgrades

6



Solar Innovation Study (SIS)

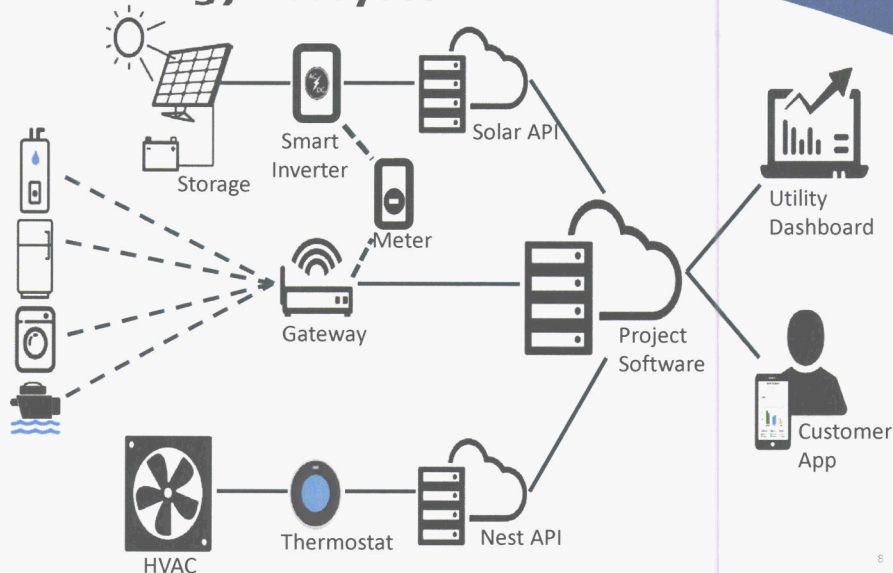
- Implement several combinations of behind the meter technologies that can be used to manage customer demand, shift load, and minimize grid challenges
- Create a rate laboratory to develop modernized demand-based residential rates to align with costs of service
- Utilize integrated technology packages (battery storage, load management, energy efficiency) to modify load shapes to better align with grid needs and future rate structure



7



Technology Ecosystem



8



Solar Innovation Study (SIS) Benefits

- Is a win for customers, market, and grid
- Tests ways that enable customers to control their demand
- Explores how DERs interact with each other to facilitate APS's transition to a smarter grid
- Provides data to expand industry-wide knowledge and to maximize use of emerging DERs in today's advanced energy market



9





Bottom Line

- APS is at the forefront of investigating combinations of solutions to solve current and future grid issues
- APS must stay ahead of distributed energy technologies in order to efficiently plan for them
- APS believes in an enabling grid



10



Thank you

Marc Romito
602-250-4547
marc.romito@aps.com

11



Energy Storage for a Clean, Affordable, Unbreakable Grid

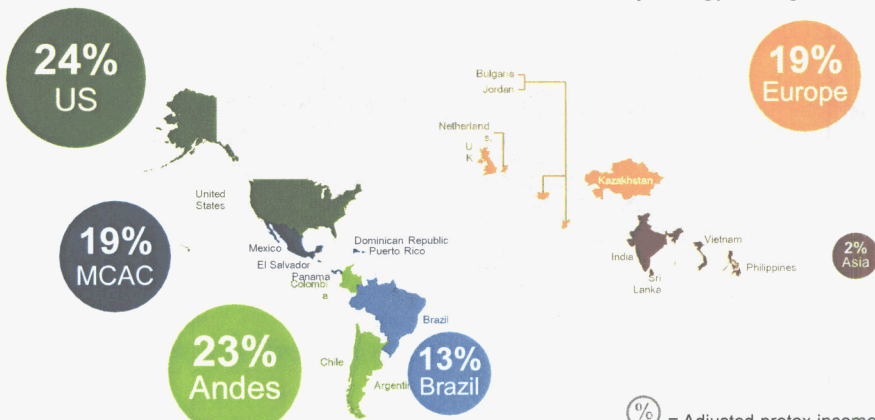
Kate McGinnis
US West Market Director, Energy Storage
The AES Corporation

October 27, 2015

The AES Corporation

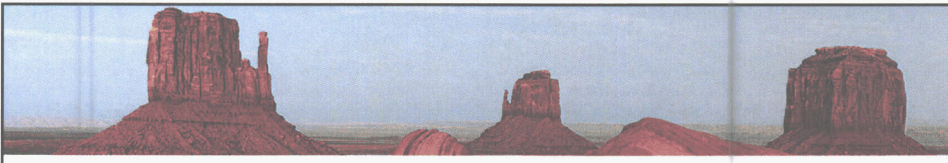
Improving lives through safe, reliable and sustainable energy solutions.

- 18 countries
- 10 million customers
- 18,500 employees
- \$39 billion assets
- 36,000 MW in operation
- world's largest battery fleet of advanced battery energy storage



Contains Forward Looking Statements

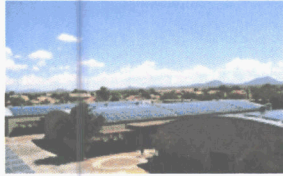

$\%$ = Adjusted pretax income
The AES Corporation. All rights reserved. 2



AES in Arizona

AES Distributed Energy has developed solar projects at 48 sites, including:

- Paradise Valley Unified School District (Phoenix & Scottsdale)
- Eloy Elementary School District (Eloy)
- Arizona Western College (Yuma)
- Boys and Girls Club (Phoenix & Scottsdale)
- Jewish Community Campus (Scottsdale)

Contains Forward Looking Statements

AES operates the largest fleet of battery-based energy storage on the power grid

Legend:

- Operations: 86 MW
- Construction: 70 MW
- Late Stage Development: 218 MW


Contains Forward Looking Statements



Electricity is fundamental to improving lives.
We have an opportunity here.


Contains Forward Looking Statements

5



Why energy storage? Why now?

- Electricity is critical, yet our system is challenged.
 - ▶ Aging infrastructure
 - ▶ Extreme weather
 - ▶ Bad actors
 - ▶ Need to be better stewards of existing resources
- Need for flexible, reliable resources.



Contains Forward Looking Statements

Photo by Feb981 and used under Creative Commons license:
https://commons.wikimedia.org/wiki/Commons:GNU_Free_Documentation_License

6

How do we maintain
and expand electricity benefits
amidst these challenges?

- ▶ meet *capacity & flexibility* needs
- ▶ improve utilization of *existing assets*
- ▶ reduce system-wide *emissions*
- ▶ support integration of *renewable* energy, AND
- ▶ increase *reliability and resiliency* of the grid?



We are doing this today with energy storage.



Contains Forward Looking Statements

7

AES' First Commercial Energy Storage Project

Installed in the Atacama Desert in 2008



24 MW Los Andes Resource
Atacama, Chile

8

12 MWi Los Andes in isolated Chilean grid is among most reliable reserve resources



Capacity Release for Generators

COD: Dec-2009
Size: 12 MWi
Commercial Availability: 100%

Loss of 200 MW in SING: November 24th

Pre-programmed digital response
when frequency dropped below 50 Hz

Effectively providing simulated inertia



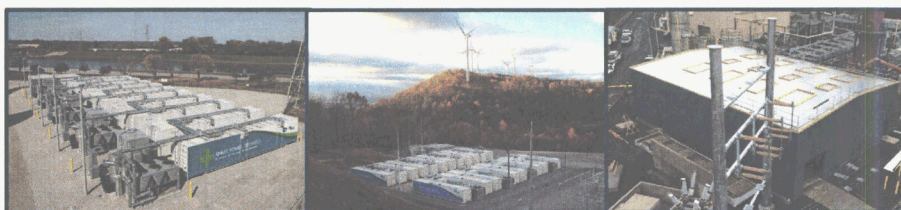
Contains Forward Looking Statements

9

Energy Storage in PJM

126 MW_r of AES assets in operation or construction

- Provides frequency regulation – balancing supply and demand
- \$20 million in savings annually
- Estimated 62,000 ton reduction in CO₂ annually



Contains Forward Looking Statements

10

Energy Storage at Southern California Edison

SCE adds 100 MW₁ of storage

- World's largest battery
 - ▶ AES awarded 20 year PPA
- Substitutes for gas-fired peaking generation
 - ▶ Selected by SCE in competitive solicitation
 - ▶ 100 MW peak power for 4 hours
 - ▶ 200 MW flexible resource



Contains Forward Looking Statements

11

Energy Storage at Indianapolis Power & Light

Indianapolis Power and Light adding energy storage

- IPL modernizing generation fleet
- Adding battery-based energy storage
 - ▶ Peak generation
 - ▶ Ramp support
 - ▶ Balance supply and demand



Contains Forward Looking Statements

12

Current Challenges for Arizona

- Capacity needs - currently being addressed by addition of peakers
- Environmental concerns related to existing coal facilities – impact of EPA Clean Power Plan
- Water concerns – drought issues
- Renewable growth potential

Contains Forward Looking Statements

13



The Next Wave of Energy Storage

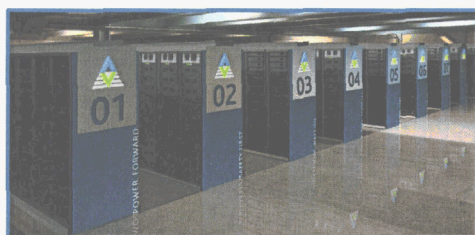
A Smart Solution

Contains Forward Looking Statements

14

Energy Storage is a Smart Investment Choice

We have the opportunity to address
a myriad of grid challenges
by embedding **energy storage** as a critical part
of our power infrastructure.



Contains Forward Looking Statements

15

Additional Benefits from Energy Storage

- Emission free with no water usage
- Rapid deployment
- No minimum generation
- Always on
- High reliability + availability
- Can perform multiple jobs, highly utilized asset

ALWAYS ON

Versus
Average
Peaker
Plant

6.6%	vs.	97%
15X		more service hours

FLEXIBLE ARRAYS

Parallel
Array
For High
Availability

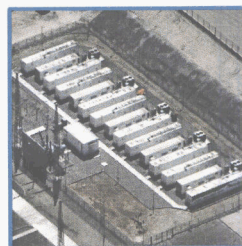
	=	ON

Contains Forward Looking Statements

16

Key Takeaways

- Energy storage is cost-effective and valuable in meeting grid challenges across generation, transmission, and distribution.
- Energy storage is *commercially available now*.
 - ▶ AES has 8 years of commercial operating experience with proven technology
- Energy storage fits in many regulatory structures.
- Energy storage is a *smart choice* to grid needs.
 - ▶ Provides peak power generation
 - ▶ Improves utilization of existing assets
 - ▶ Reduces system-wide emissions
 - ▶ Supports integration of renewables
 - ▶ Increases reliability and resiliency of the grid



Contains Forward Looking Statements

17

Thank you.



Kate McGinnis
 Market Director, AES Energy Storage
www.aesenergystorage.com
kate.mcginis@aes.com



Energy Storage:

The Final Frontier in
Energy Technology

A Presentation to
Arizona Corporation Commission
Emerging Technologies Workshop

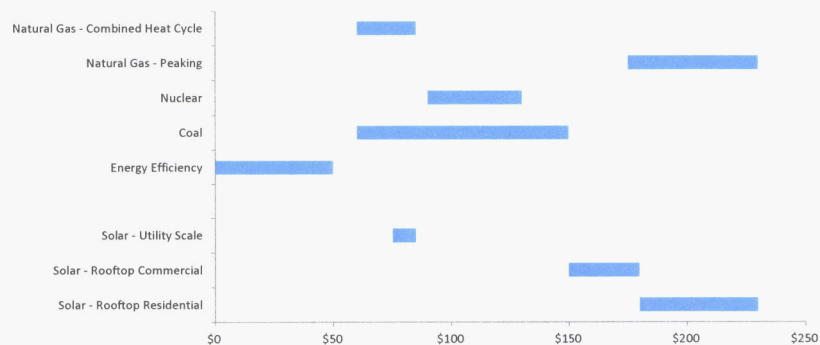
By
Farid Dibachi
CEO, JLM Energy, Inc.

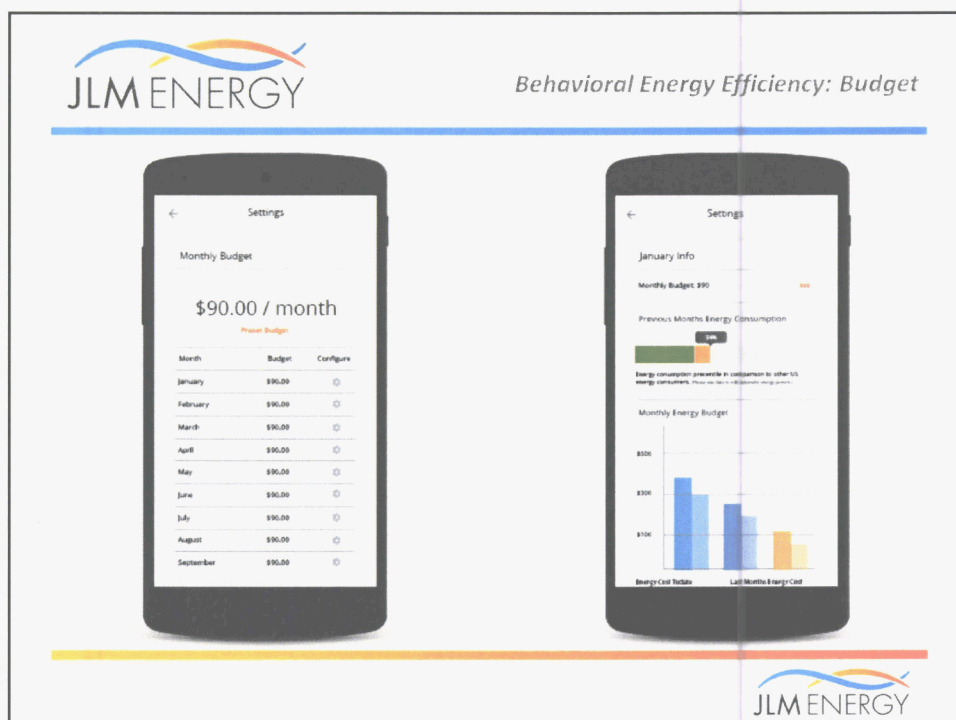
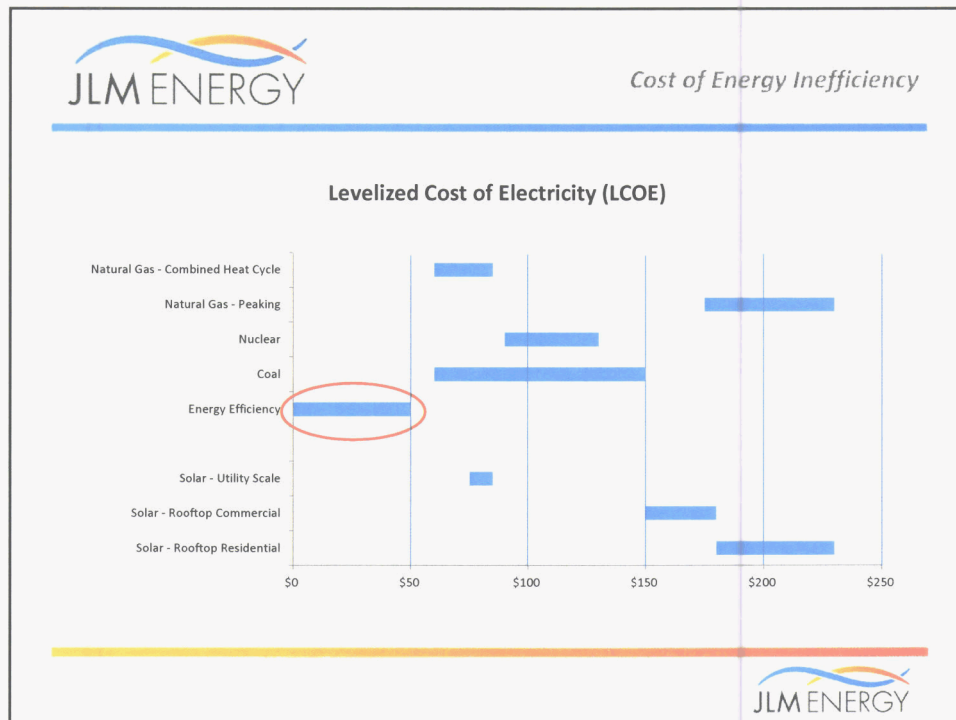


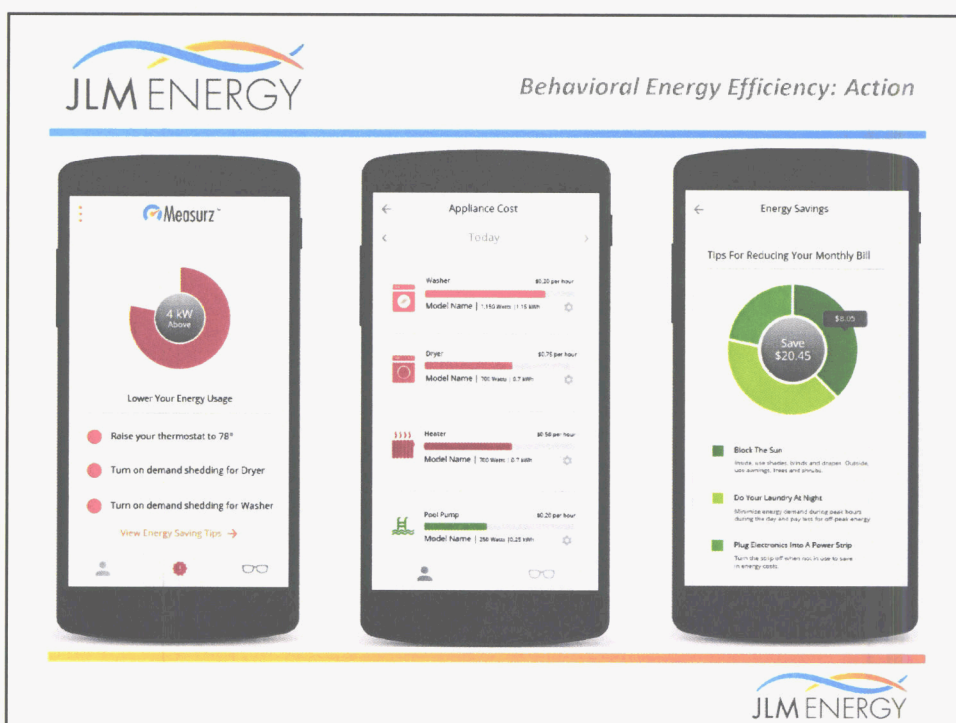
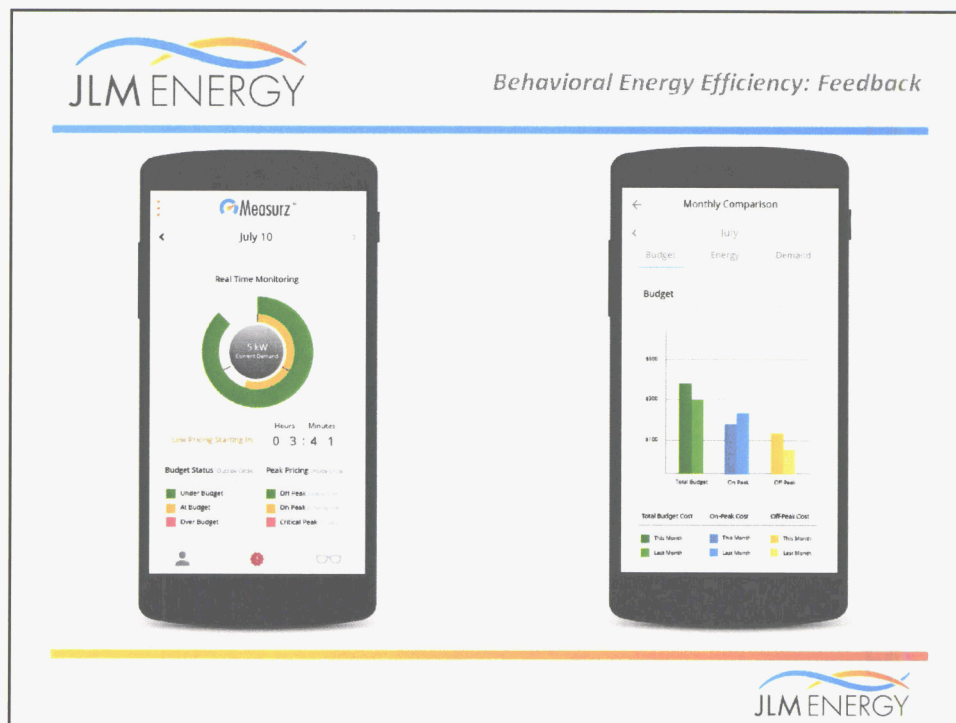
Levelized Cost of Electricity

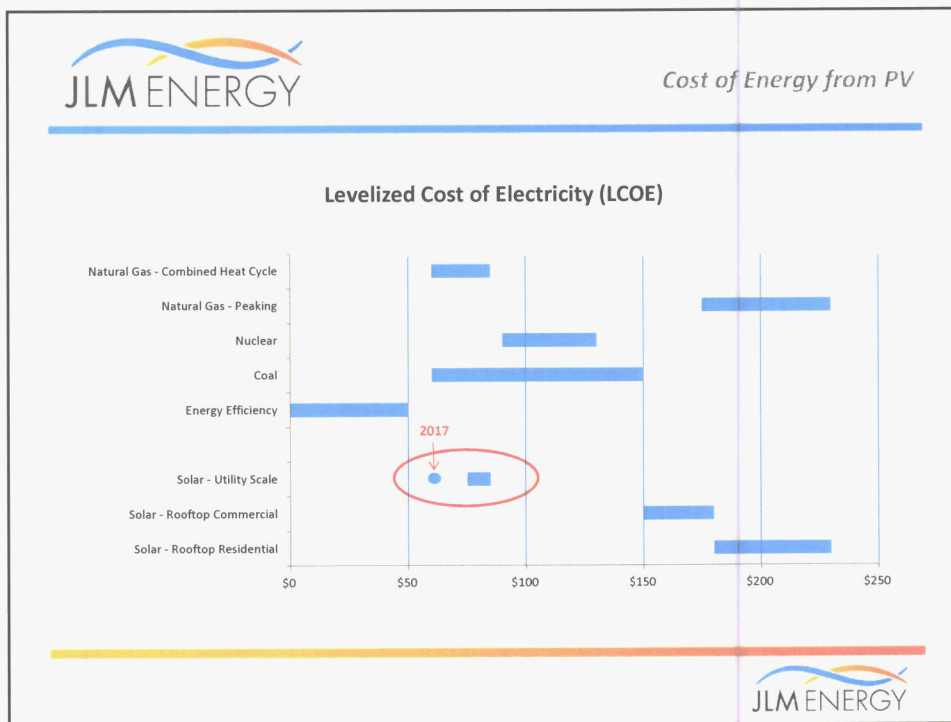
Levelized Cost of Electricity (LCOE)

1. Energy Efficiency
2. PV Solar
3. Battery Energy Storage









JLM ENERGY *PV Solar: Challenges & Opportunities*

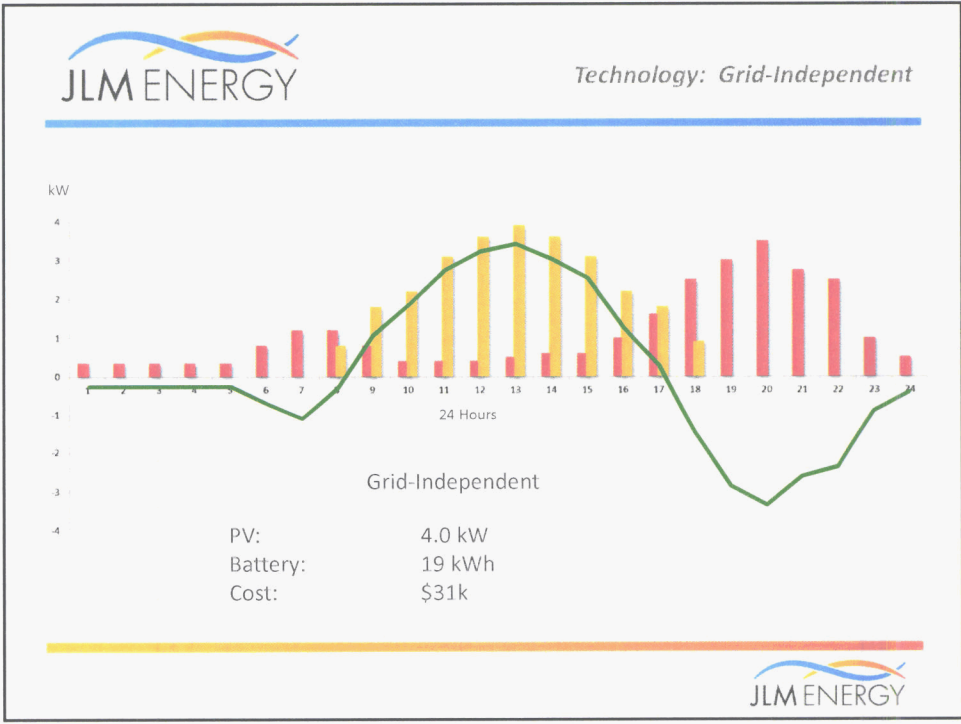
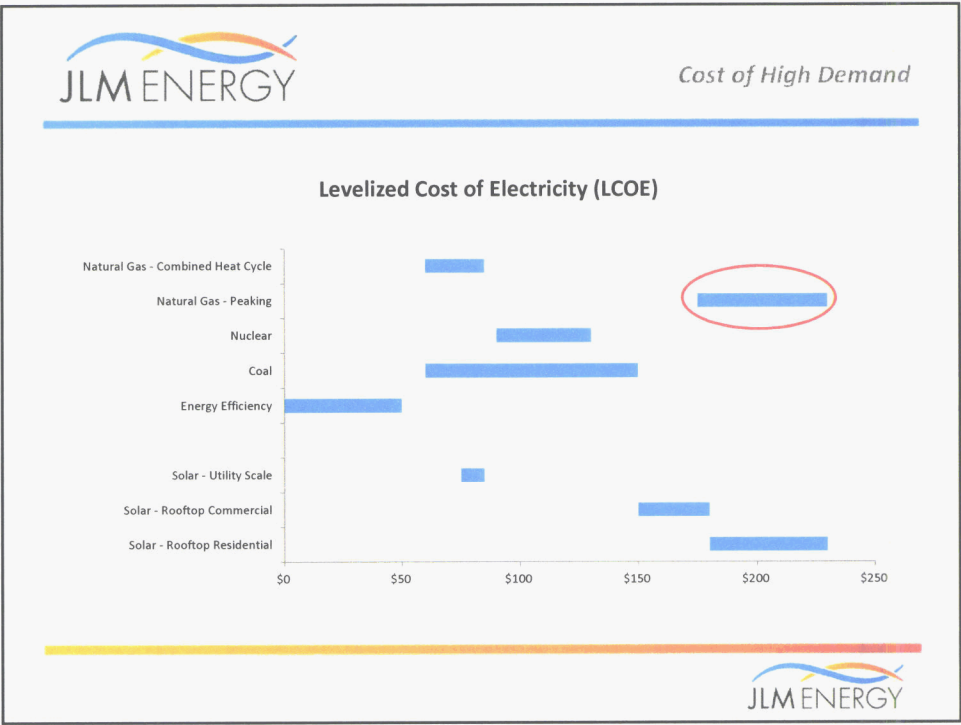
Challenges:

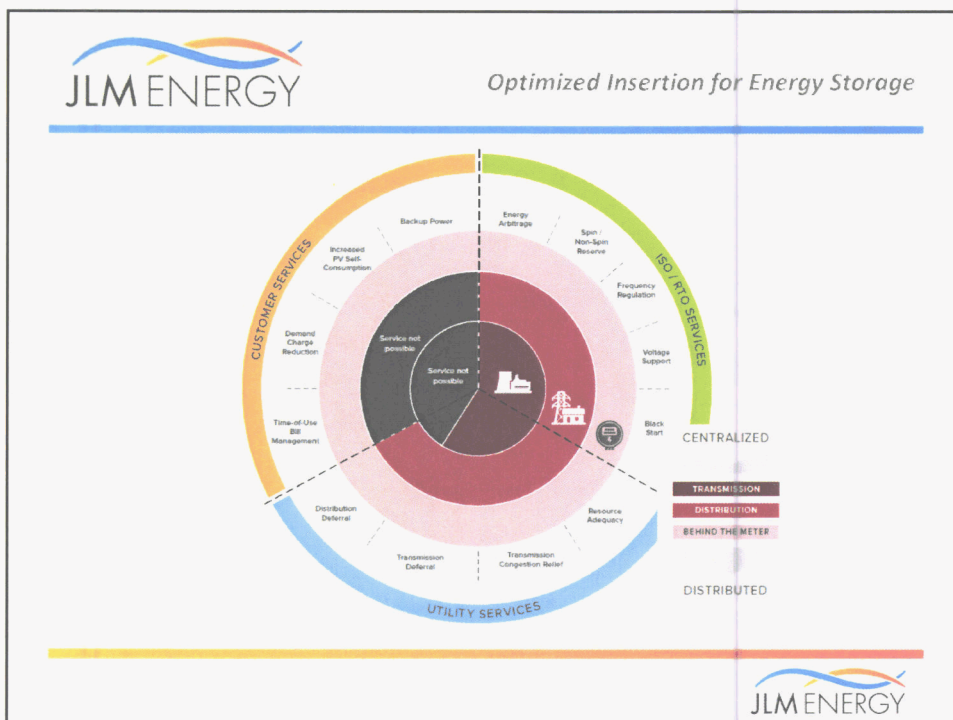
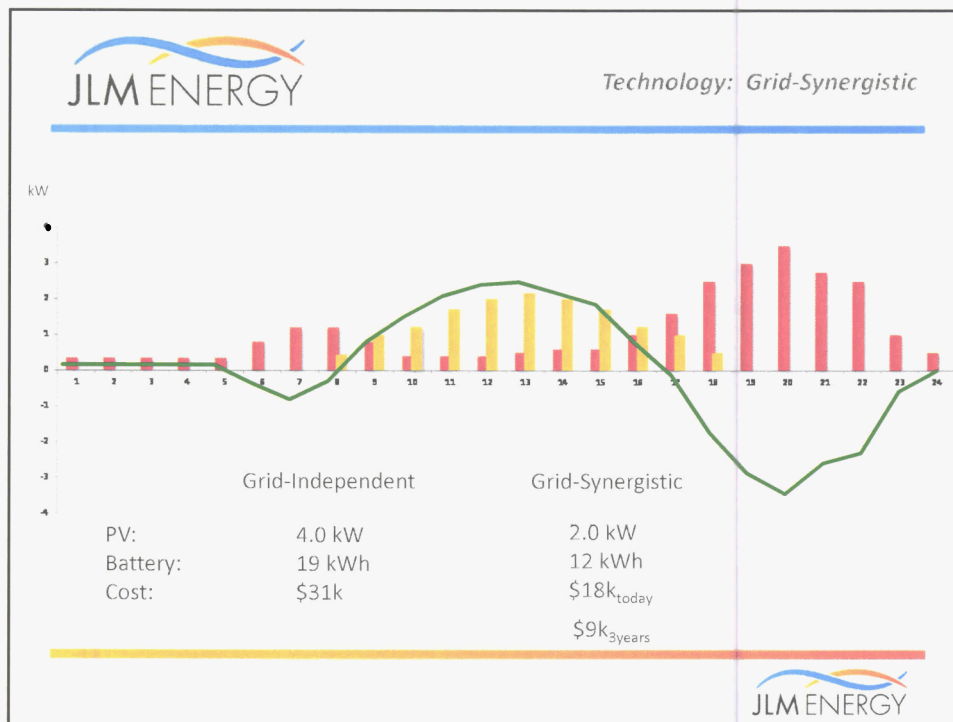
- ❖ Only producing 4 to 5 hours a day
- ❖ Intermittent
- ❖ Strain grid resources

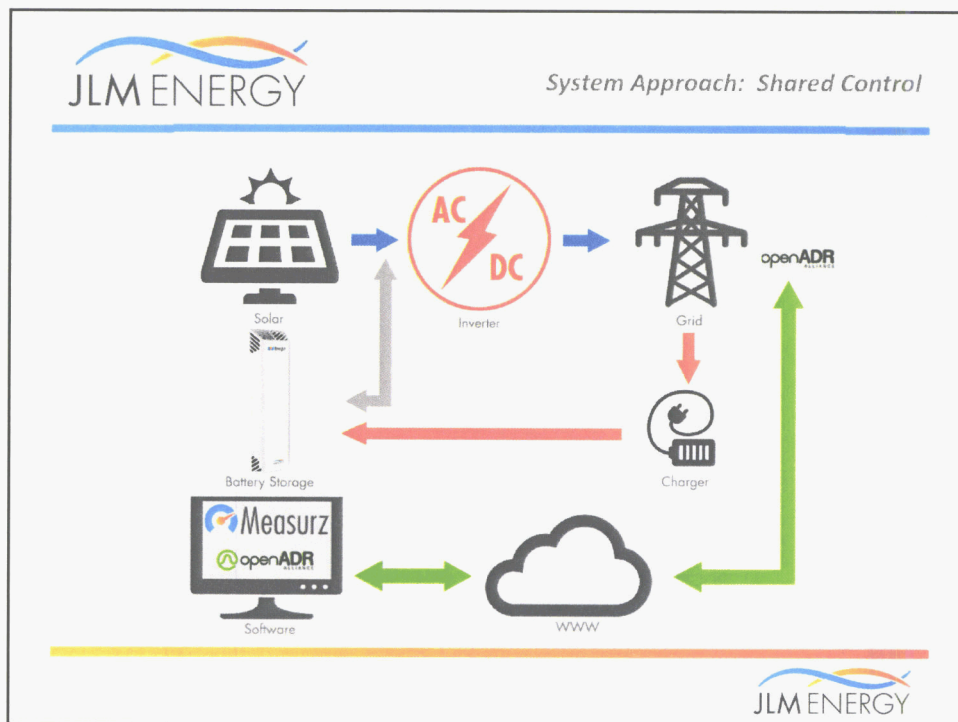
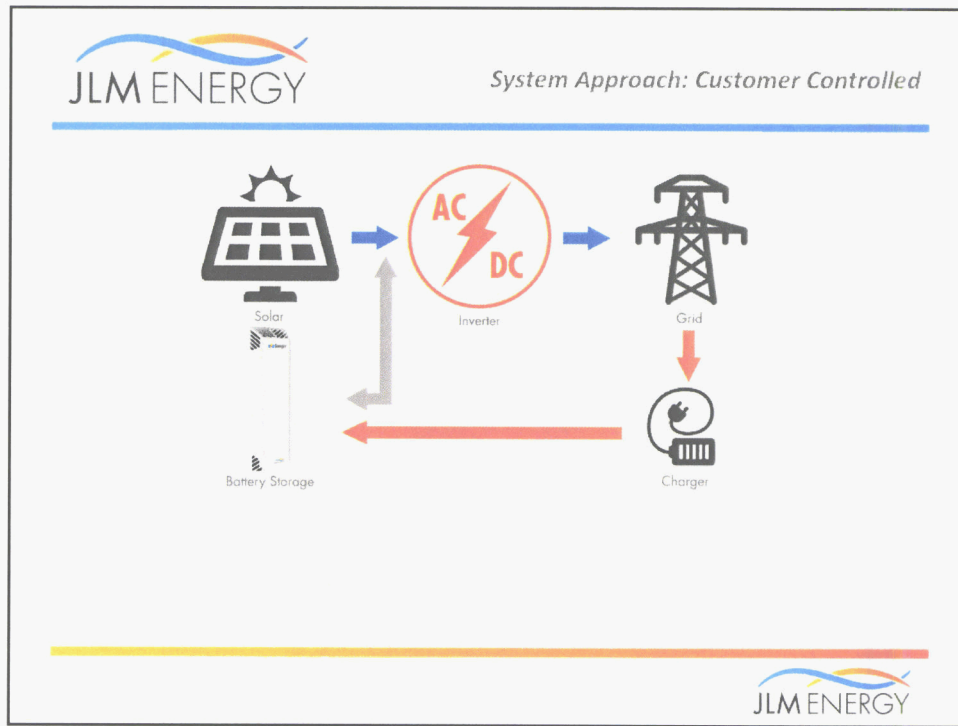
Opportunities: Energy Storage

- ❖ Self-consumption
- ❖ Demand Shaving
- ❖ PV Smoothing

JLM ENERGY









Conclusions: Technology-driven Energy

Three-pronged approach:

1. Energy efficiency
2. Photovoltaics energy generation
3. Energy storage

1. Energy Efficiency:

- ❖ Technology-enabled; *the Behavioral kind*

2. Photovoltaics

- ❖ Plummeting costs
- ❖ Coupled with storage

3. Energy storage works best when:

- ❖ in conjunction with the grid
- ❖ installed behind the meter
- ❖ controls are shared between the Utility and its customers



Thank You!

Farid Dibachi
farid.dibachi@jlmei.com





Unlocking the Potential of Distributed Energy Resources

Kevin Joyce, Manager
Grid Engineering Solutions
October 27, 2015

Executive Summary

The capability and value of a modern distributed grid is available today and can be realized through integrated distribution planning.

- Demonstrated DER Capability – Aggregated Distributed Energy Resources (DERs), including smart inverters, storage, and load control devices are demonstrating the ability to supply grid services, like distribution system capacity and power quality.
- Value to Ratepayers – When deployed as an alternative to traditional distribution infrastructure investment, aggregated DERs can address key challenges of infrastructure planning at a lower cost.
- Integrated Distribution Planning – DER potential can be better realized with adjustments to the current approach to distribution planning. By considering DERs in interconnection, planning, and sourcing process and sharing enabling data with the market, DERs can address grid needs, reduce cost and be flexible assets to the grid.

SolarCity

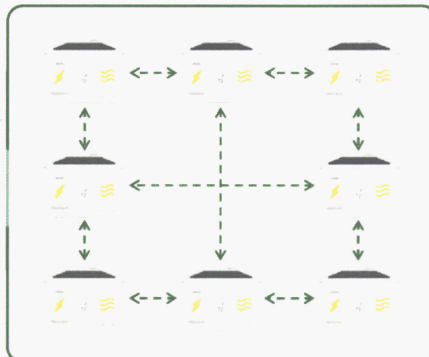
Distributed Energy Resource Aggregation

Utilize portfolios of distributed energy resources to provide grid services

Distributed Energy Resources (DERs)



Aggregated DER Portfolios



Grid Services

Voltage Support

Distribution Capacity

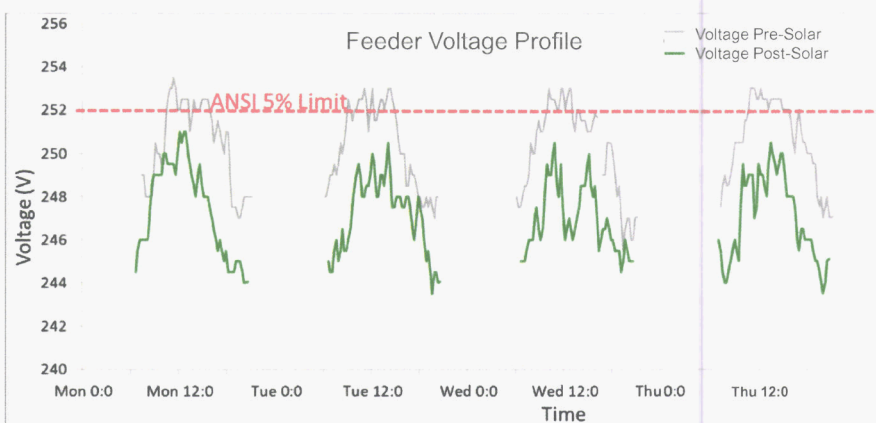
Demand Management

Reactive Power Support

SolarCity

Field Results: Voltage Support

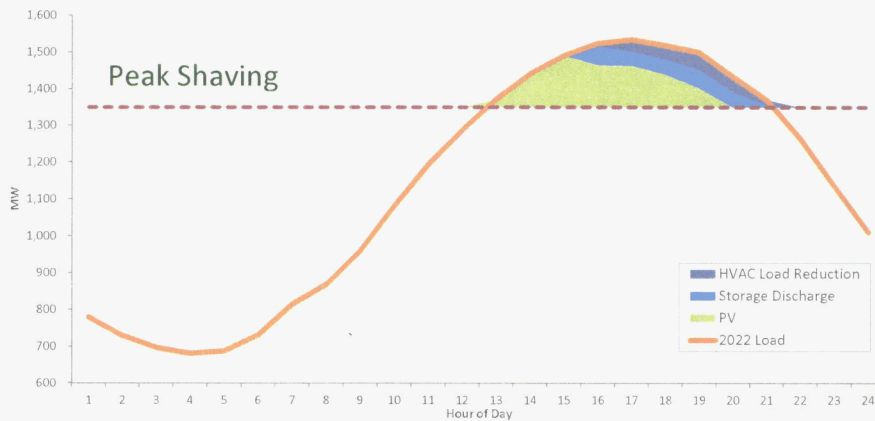
Solar with smart inverters eliminated need for line regulator to solve pre-existing high voltage condition



Deployment included 275 inverters and 5MW of PV

SolarCity

Distributed resources can reduce peak loads on distribution system circuits



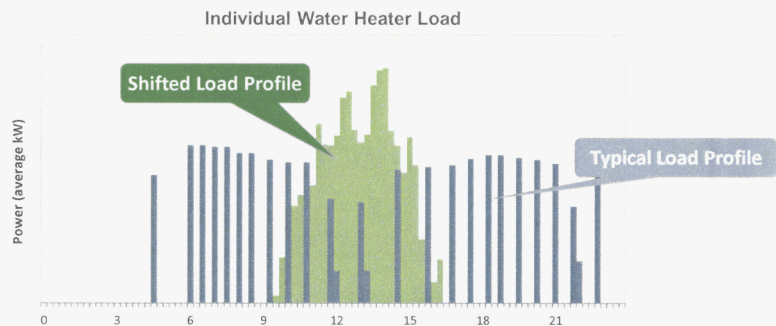
- SolarCity simulated results for a distribution circuit in Southern California Edison territory
- PV can significantly reduce peak load conditions on distribution circuits on its own

SolarCity

Dynamic Load Control

Electric water heaters and dynamic load control devices deployed to increase local PV absorption

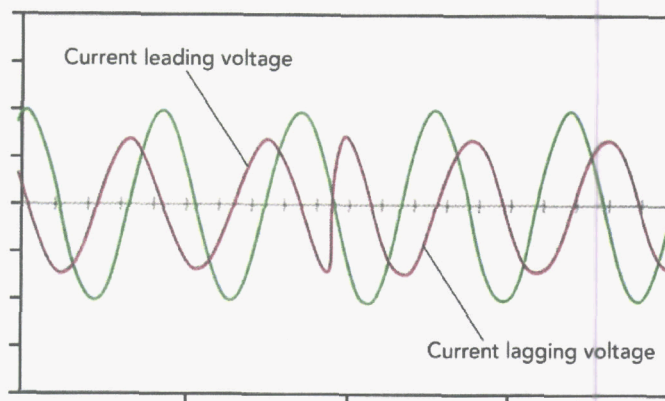
- Heat water while PV is generating power
- Store hot water for later occupant use (no impact on resident comfort)
- Utilize PV over-generation



SolarCity

Reactive Power Support

Smart inverters can provide reactive power support in less than one cycle



Similar reactive power support is typically provided by costly capacitor banks

SolarCity

Dynamic Aggregated Control proven in the field with 190 inverters, and validated by NREL



Test Name	Test Description
Rapid Change in Load	Simulate a rapid loss of load for a given deployment site and evaluate the response from DERs to increase net load
Fast Solar Down Ramp	Simulate a rapid decrease in solar irradiance and evaluate the subsequent response of the site to maximize generation output
Fast Solar Up Ramp	Simulate a rapid increase in solar irradiance and evaluate the subsequent response of the site to manage the net load ramp within specified levels
Load Tap Change	Simulate a load tap changer operation and evaluate the subsequent response from DERs to increase or decrease net load
Circuit Switch Opens	Simulate the loss of a large load on the distribution circuit and evaluate the subsequent response from DERs to increase net load to prevent reverse power flow
Circuit Switch Closes	Simulate the addition of a circuit with solar inverters that are not under the control of this product and evaluate the subsequent response to increase net load
Fault Protection	Measure system time to respond to a fault that effects the steady state operation of a given deployment site
Reverse Power Flow	Simulate reverse power flow at the feeder, substation, main substation, and transmission and evaluate the subsequent response to increase net load

SolarCity

SolarCity is collaborating with utilities on a number of projects



- Researching solutions for common PV integration challenges, including transient overvoltages, smart inverter voltage support, and multi-inverter anti-islanding



- Deploying 50 smart energy homes to demonstrate the ability to provide distribution capacity support, voltage support, and systems-level ancillary services



- Deploying 700kW of advanced inverters to demonstrate the inverter's ability to provide distribution voltage and reactive power support

SolarCity

DER Value to Ratepayers

Challenges of Infrastructure Planning

	Challenge	Solution	Principle
1	Bulky investments introduce underutilized infrastructure capacity	Smaller, <u>incremental investments</u> increase infrastructure utilization	Time value of money
2	Forecast errors introduce underutilized infrastructure capacity	<u>Shorter lead time</u> infrastructure solutions reduce forecast error	Real option value
3	Contingency planning for "N-1" scenarios	Deploy <u>smaller assets</u> to spread risk	Portfolio diversification

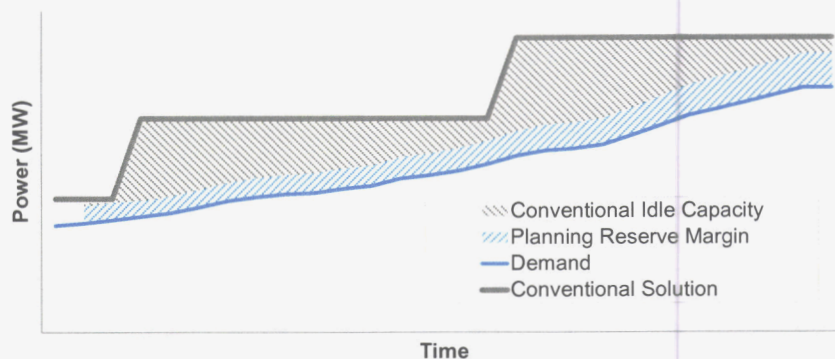
Distributed resources offer solutions to planning challenges that reduce the costs of electric service for ratepayers

SolarCity

Conventional planning is bulky

Illustrative

Conventional Planning

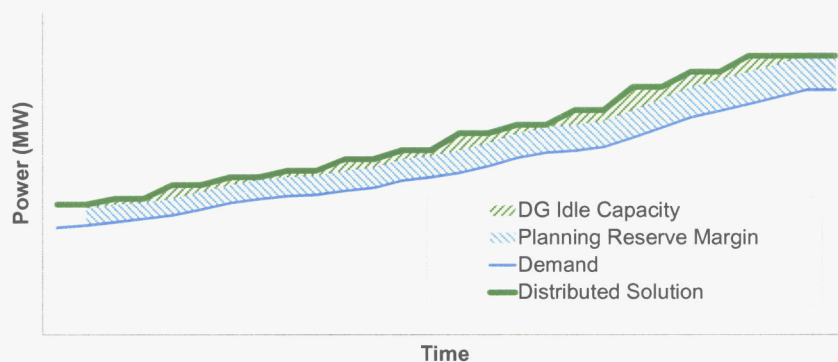


SolarCity

Smaller building blocks enable more targeted deployments

Illustrative

Targeted Planning



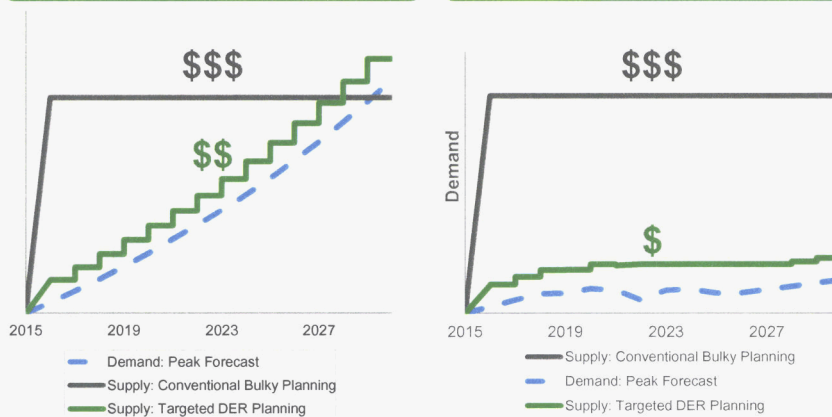
SolarCity

Real Option Value prevents expensive overbuilds

Illustrative

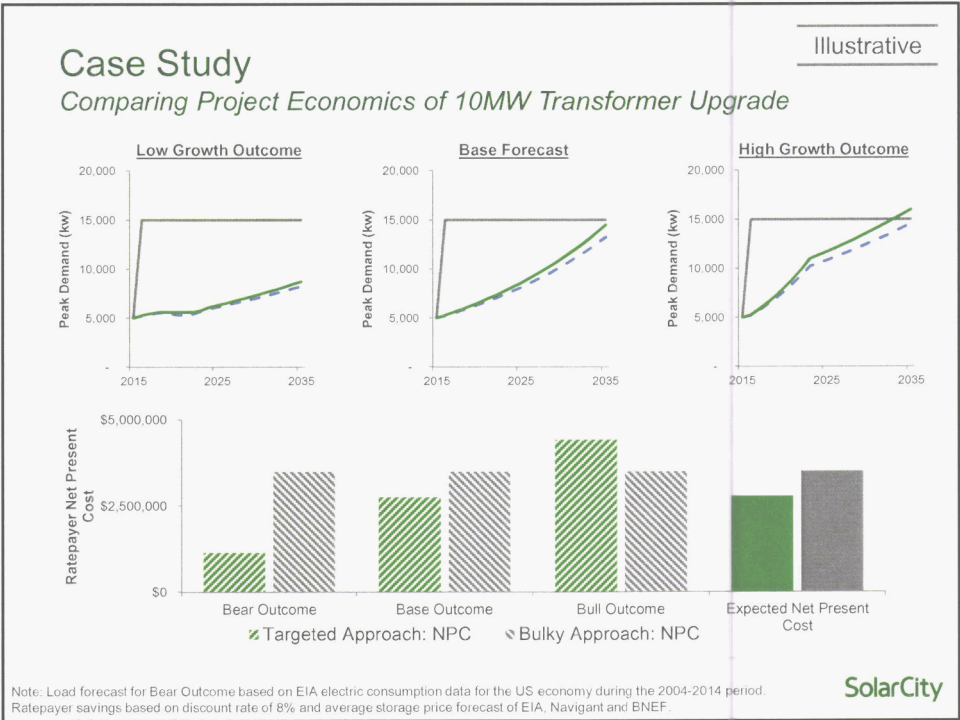
Base Utility Forecast

Low Growth Outcome



Note: Load forecast for Bear Outcome based on EIA electric consumption data for the US economy during the 2004-2014 period.
Source: Forecast errors based on EIA's Annual Energy Outlook (AEO), Years 2001-2013

SolarCity



Integrated Distribution Planning

Modernization of Planning for Distribution can Unlock Distributed Energy Resource Potential

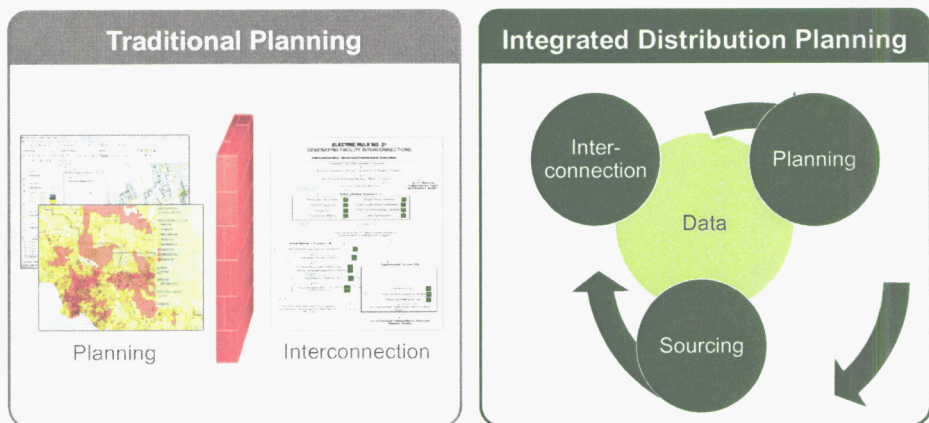


Image Sources: CIME, NREL, EPRI

SolarCity

Example project where distributed energy resources can lower costs

- The Mazatzal 345kV AC/150MVA substation project was approved for **\$23.6m** in 2011 to support the community around Payson, AZ, a community of 15,000 people located in national forest land 90 miles NE of Phoenix.
- APS will build a 345 substation with a 150MVA transformer and two double-circuit 69/21kV sub-transmission lines for the primary distribution system
- APS Alternatives considered:
 - Three alternative substation sites on private land but could not find appropriate sites
 - Higher voltage lines to eliminate the need for multiple sub-transmission lines, but power capacity exceeded need.
 - Undergrounding lines
 - **No DER solutions considered**

SolarCity

Plan for Load and for DERs

Challenge: Utility planning processes do not leverage DERs to provide grid services, lower system costs, and increase resiliency

Approach: Modernize distribution planning to leverage DERs

1

Forecast Growth & Maintenance

Forecast load and DER growth and required equipment maintenance

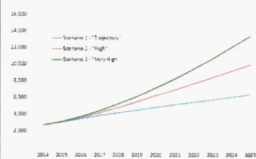


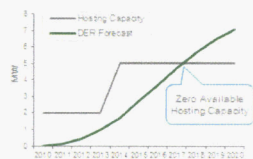
Image Source: Pacific Gas & Electric

Incorporate DER growth in addition to load growth forecasts

2

Identify Needs

Compare growth to available hosting and circuit capacities



Zero Available Hosting Capacity

3

Evaluate Options

Evaluate solutions to meet identified needs, including the use of DER portfolios

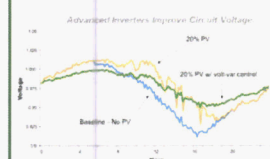


Image Source: EPRI

Include DERs as an option to proactively meet grid needs

SolarCity

Modernize Sourcing

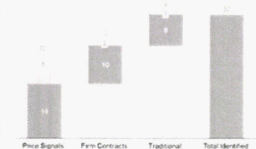
Challenge: Utility distribution sourcing does not leverage DERs to provide grid services, lower system costs, and increase grid resiliency

Approach: Modernize distribution sourcing to evaluate, select, and deploy DERs to meet grid needs

1

Select Least Cost / Best Fit

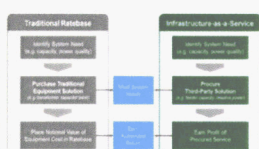
Identify least cost / best fit portfolio of DER and traditional assets



2

Deploy Resources

Conduct pricing, program and procurement efforts to obtain needed assets



3

Monitor Performance

Monitor, measure and verify performance, adjusting portfolio as needed



Select least cost / best fit portfolio, including DERs rather than solely traditional infrastructure

SolarCity

Thank you

Data and Controllability

Asset Type	Data	Control
Base Inverter	AC current, AC voltage, AC power, Frequency, Apparent power, Reactive power, Power factor, AC lifetime energy production, DC current, DC voltage, DC power, Onboard temperature, Operating state	Anti-islanding protection
Smart Inverter	AC current, AC voltage, AC power, Frequency, Apparent power, Reactive power, Power factor, AC lifetime energy production, DC current, DC voltage, DC power, Onboard temperature, Operating state, DC over voltage, AC disconnect, DC disconnect, Grid disconnect, Over temperature, Over frequency, Under frequency, AC over voltage, AC under voltage, Under temperature, Grid AC over voltage, Grid AC under voltage, Grid AC over current, Grid AC under frequency,	Anti-islanding protection, Low and High Voltage Ride Through, Low and High Frequency Ride Through, Dynamic Volt/VAR Support (4 quadrant P-Q support), Ramp Rate Control, Fixed Power Factor, Soft Start Reconnection, Remote upgradeability
Load meter	AC current, AC voltage, AC frequency, AC power, AC apparent power, AC reactive power, Power factor, Exported energy, Imported energy, Exported apparent energy, Imported apparent energy, Exported reactive energy, Imported reactive energy	Use load meter data to inform the control of other assets for optimal local and portfolio-level energy management
Electric Water Heater	Power, Energy consumption, Stored energy, Storage capacity, Max Power, Min Power, Element on %, Grid frequency, Temperature (avg, inlet, outlet, top, middle, bottom), Control signals,	Individual tank control, Aggregated fleet control, 0-100% variable power consumption, Load shifting, Self-consume PV generation, Demand response, Frequency regulation up/down

SolarCity

Data and Controllability

Asset Type	Data	Control
Battery	Energy nameplate, Rated power, Nominal voltage, Energy available, Energy required for charge, State of charge, Max charge power, Max discharge power, AC inverter power, DC inverter power, AC current, Temperature, DC voltage, DC current, AC lifetime exported energy, AC lifetime imported energy, DC lifetime exported energy, DC lifetime imported energy, Status, Faults, Alerts, System events, - (inv) - Pack voltage, Pack Amps, Max apparent power, Max active power, Max reactive power, CosPhi/Q control mode, Apparent power limit, Active power limit, Reactive power limit, Timeout, Fallback active power limit, Fallback reactive power, Fallback CosPhi, Active power ramp up rate, Active power ramp down rate, Reactive power ramp up rate, Reactive power ramp down rate, CosPhi change rate, Dynamic active power limit, Dynamic reactive power reference, Dynamic CosPhi reference	Charge, Discharge, Power factor, Set max power
Thermostat	Temperature, target temperature, target temperature upper limit, target temperature lower limit, ambient temperature, humidity, location, online status, can heat/cool, fan status, emergency heat, away temperature, hvac mode, hvac on time, home/away status, ETA, peak period start/end time	Adjust temperature, Turn hvac on/off, Fan on/off, Pre-cooling, Demand response, Peak price period energy reduction, Energy event control/optimization

- All data available in real-time (up to 1 second granularity) and historical
- Data can be aggregated (i.e. substation, pricing node, service transformer, etc)

SolarCity



APS Solar Innovation Study

- Study will include 75 participating homes installed with solar PV and various configurations of:

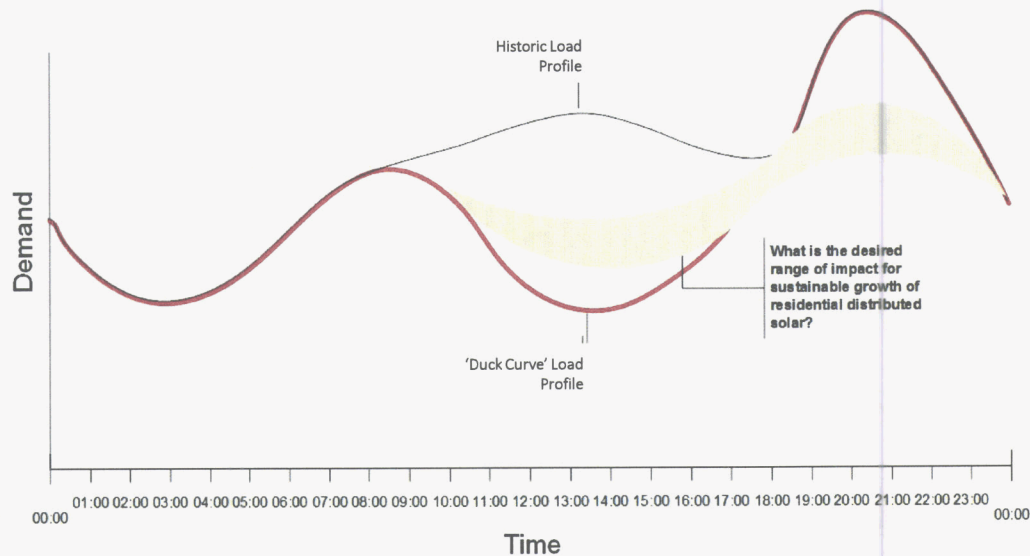
- battery storage
- energy efficiency
- smart thermostats
- demand response controls

All connected through a
cloud based home energy
management system

- Objectives

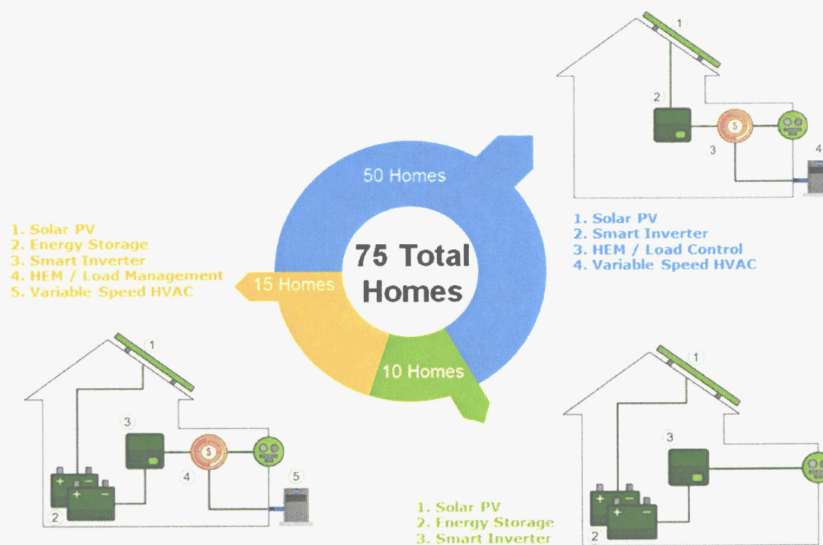
- Identify effective technology packages that can shift loads of solar homes to minimize 'duck curve' challenges.
- Gain insights into customer behavior and preferences in use of 'next generation' demand control and load shifting technologies.
- Identify ways to help customers respond to demand based price signals using energy management technologies.

Managing Solar Home Load Shapes



3 **TIERRA**
Resource Consultants, LLC

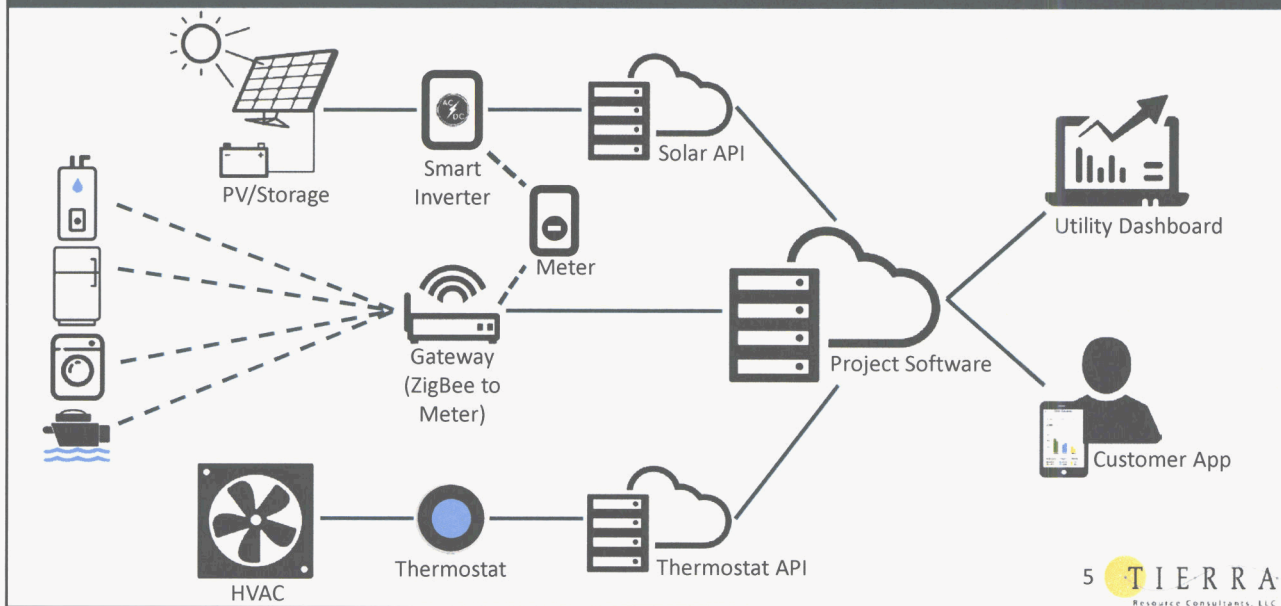
Project Overview



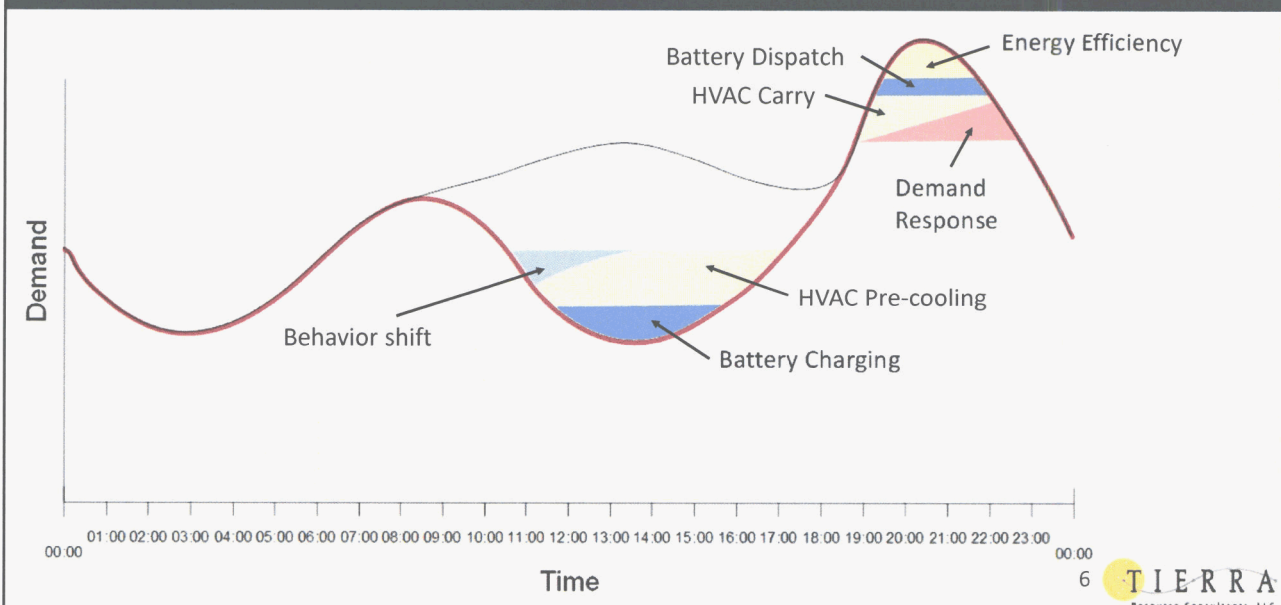
- Field research with 75 existing single family homes
- Includes newly installed APS owned/operated energy technologies
- Includes both high efficiency (ENERGY STAR) homes and standard efficiency homes

4 **TIERRA**
Resource Consultants, LLC

Solar Innovation Study Technology Ecosystem



Resulting Load Impacts from the Technology Ecosystem



Participant Insights

If participants have automated technology to help manage their energy usage, how will they use it to respond to demand based rates?

- **Awareness** – ('Perceived Behavioral Control') Did participants become more aware of their energy use and how technologies can help them manage energy use and cost?
- **Knowledge** – What was the level of knowledge of energy management before and after the study? How can this inform rate design?
- **Attitude** – How did participants' attitudes about energy management change? Were certain tech combinations or operating protocols more acceptable than others?

Participant Insights

- **Ease of use** – ('Ease of Behavior') Were the technologies easy to use, both individually and at the system level?
- **Comfort** – ('Convenience/Ease') Were there times when the system operation caused participants to be uncomfortable? How did they react? How many times did they override?
- **Behavior** – Did the technology cause participants to change their lifestyle or behaviors towards using energy? In what ways?

Project Timeline/Next Steps

- Currently finishing technology evaluations and selection
- Finalizing analytic plan
- Targeted to begin installations in Q1 2016

Questions?

Marshall Keneipp
Marshall.Keneipp@tierrarc.com
303-913-8113



Using Advanced Analytics to Increase Program Participation

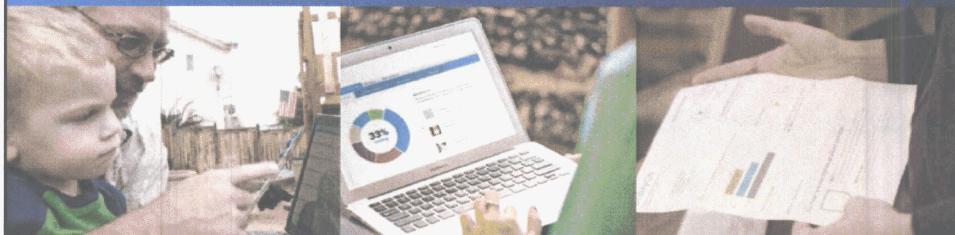
October 27, 2015

OPOWER'S CUSTOMER ENGAGEMENT PLATFORM
POSITIONS UTILITIES AS TRUSTED ENERGY ADVISORS
TO THE CUSTOMERS THEY SERVE.

SERVING **95** UTILITY CLIENTS

ANALYZING MORE THAN **500 BILLION** METER READS

ENGAGING **50 MILLION** HOMES AND BUSINESSES



Opower in Arizona and the Southwest



AZ Impact to date (2010-Current)



600,000+ households served with reports and web tools



134 GWh lifetime electric savings



\$14.7 MM+ in customer bill savings



92,400 metric tonnes of CO2 abated

Opower impact in the SW Region

2.6 MM+ households served with reports and web tools

381 GWh lifetime electric savings

\$40 MM+ in customer bill savings

262,719 metric tonnes of CO2 abated

3

Opower Confidential

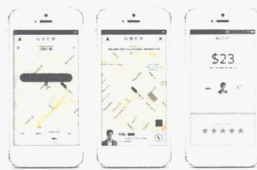
Consumers expect more than ever



Frictionless Experience

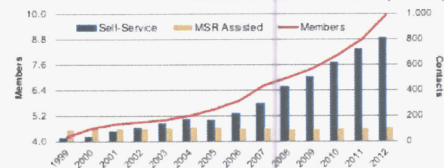


Self Service Advice



REQUEST Tap to request a service location
BOOK Select a service location, set your own price and duration
RATE Rate your service location, set your own price and duration

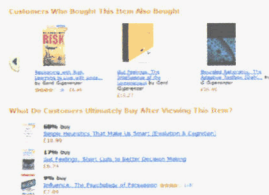
USAA Members and Contacts (Millions)



amazon Predictive Analytics

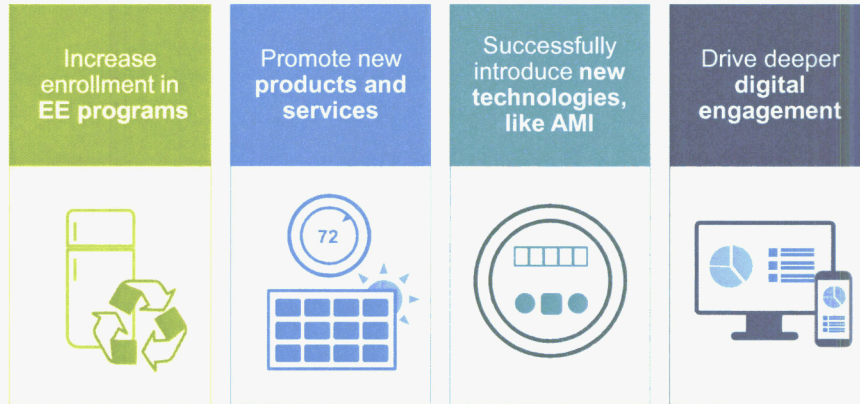


Personalized recommendations



Opower Confidential

Utilities have new priorities




5 | Opower Confidential

Yet, most utility marketing still looks like this



6 | Opower Confidential

Fortunately, utilities have the data to do better

Consumer	Rate	Behavioral	Demographic	Psychographic	Weather
					
Cust ID Premise Account	Rate Code Rate ID Rate History	Avg. Usage Peak Usage Load Curve	Age Sq. Ft Income	Green Frugal Techy	Avg. Temp Peak Temp Current Temp

7 | Opower Confidential 



So, how do we put
this data to work?

Case Study 1: Load Curve Archetypes

Hairball:

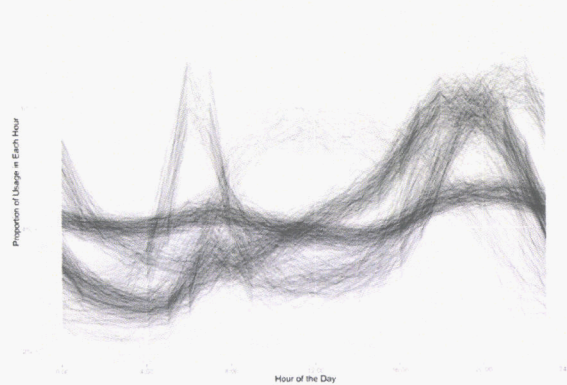
Load Curves From 1,000 Customers



9 | Opower Confidential

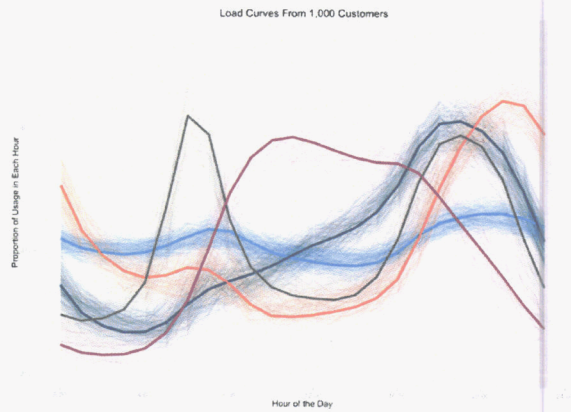
Finding signal in the noise

Load Curves From 1,000 Customers



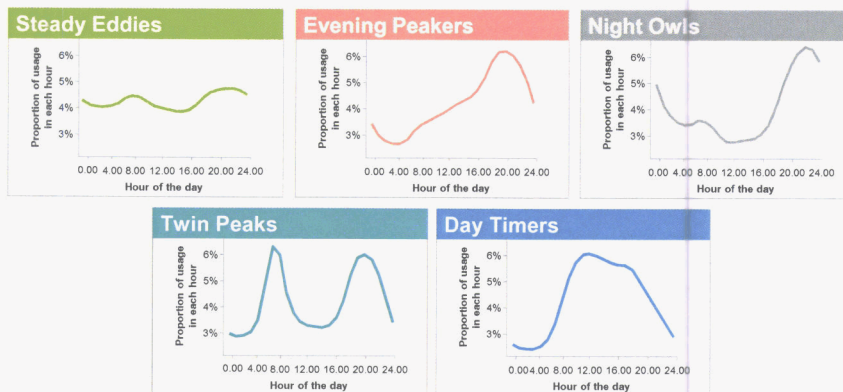
10 | Opower Confidential

Deciphering a pattern



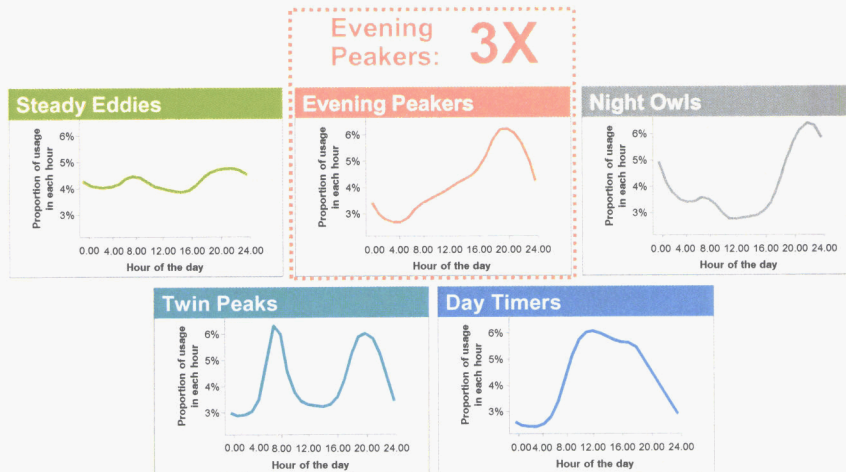
11 | Opower Confidential

Enter the AML archetypes



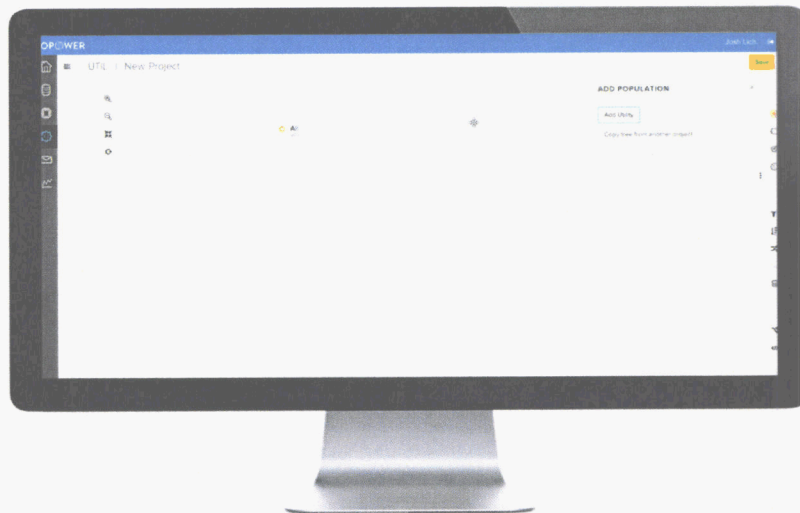
12 | Opower Confidential

Which archetype responds best to DR signals?



12 | Opower Confidential

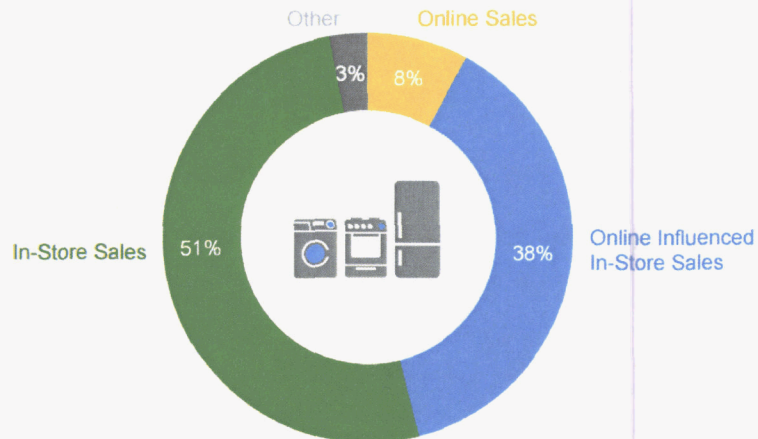
Utilizing robust segmentation to increase participation and reduce cost



14 | Opower Confidential

Case Study 2: Utility Marketplace

Over half of large appliance purchases originate online



15 | Opower Confidential

Yet, most appliance rebate pages look like this

Residential Efficiency Programs & Rebates

UtilityCo electric supply is now carbon neutral, but you can still make efficiency improvements at your home to lower your energy and water consumption, and save on your utility bills.

Benefits when you improve efficiency:

- ▶ Save money by reducing electric charges on your utilities bill
- ▶ Reduce the environmental costs for new transmission lines to bring energy from remote generators
- ▶ Reduce the amount of renewable energy the City must buy for the community, using less power from ANY energy facility reduces our impact on the environment
- ▶ Reduce peak demand

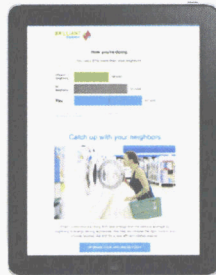
Contact us if you have questions about our programs and rebates.
Join our eNews mailing list to get updates on workshops and programs.

If you don't find it here, call (650) 329-2241 for more info.

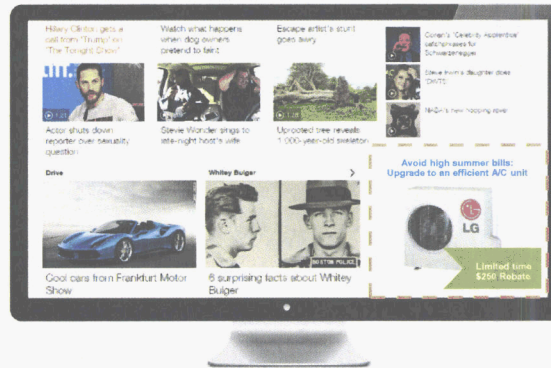
16 | Opower Confidential

Using digital advertising to bring utility rebates to the digital age

Personalized email



Online ad targeting



OPower

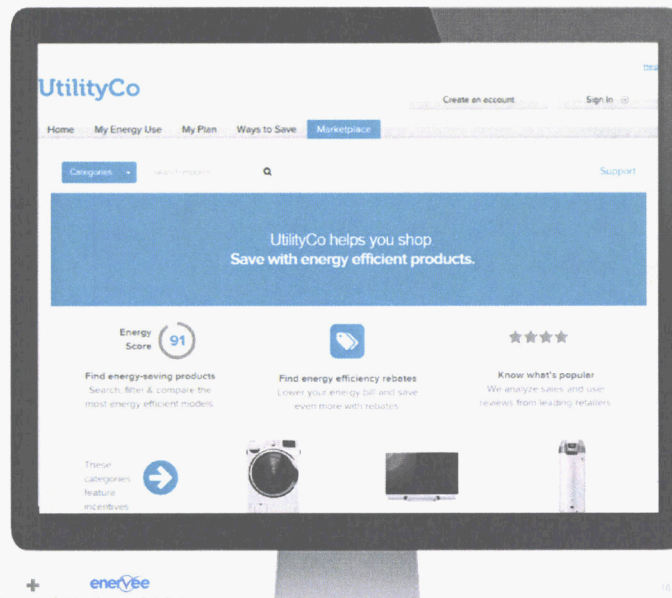


EnergyCo

17 | OPower Confidential



Robust ecommerce marketplace increases uptake of utility programs



OPower



EnergyCo

18 | OPower Confidential

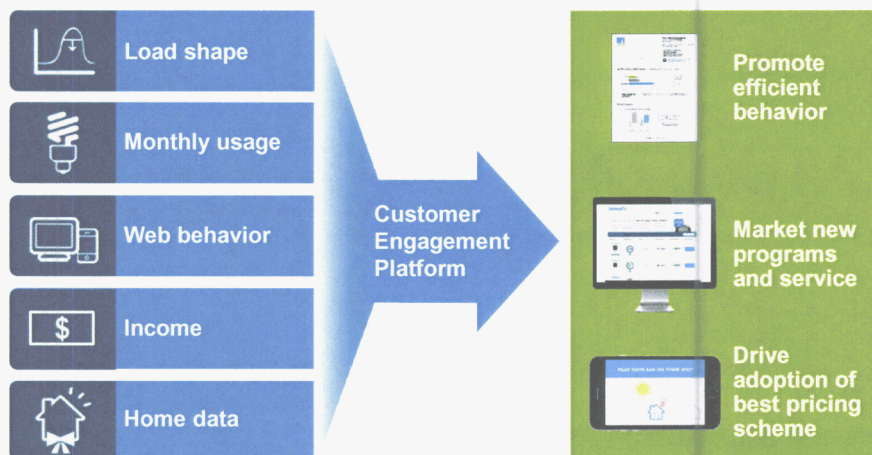




Where are we going from here?

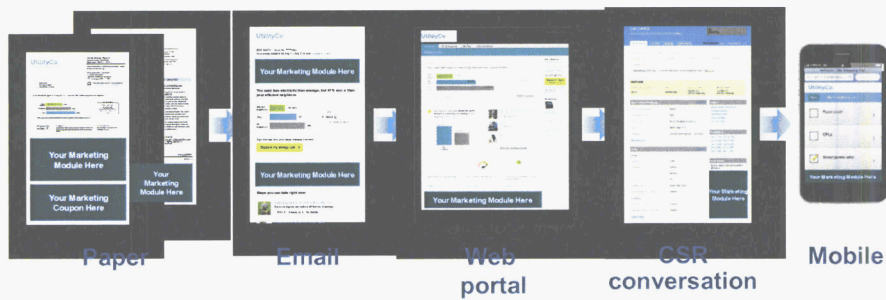
19 | Opower Confidential

Where we're going: Utilities as trusted advisors to their customers on all energy decisions



20 | Opower Confidential

Where we're going: Personalizing every customer touchpoint



21 | Gpower Confidential

Thank you!